FREE! Star Map Inside!

ASTRONOMY

August 1984

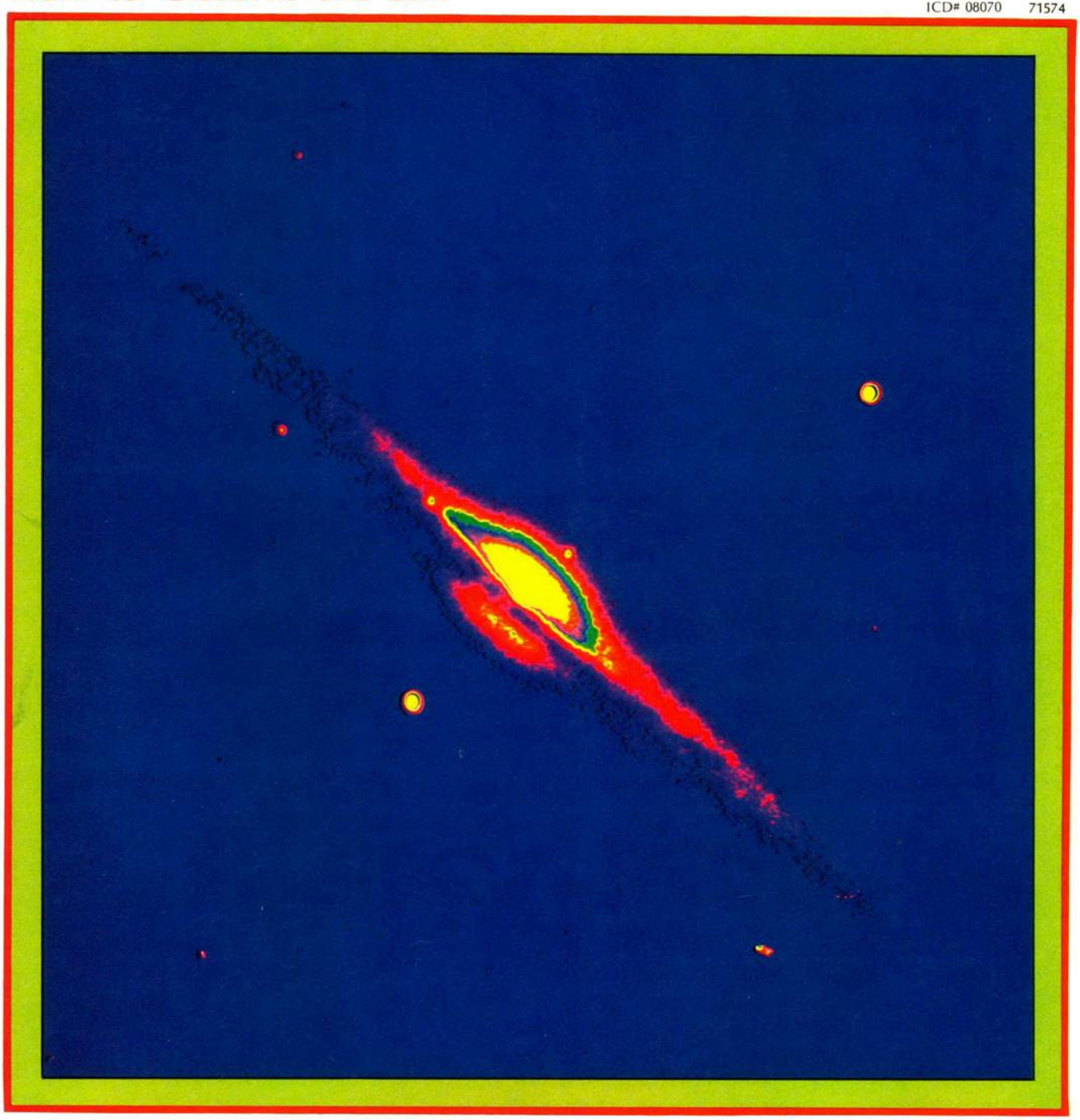
U.S. $2
UK £1.25
Can. $2.50

Astronomical Ballooning

HM Sge: The Rekindled Star

How to Observe the Sun

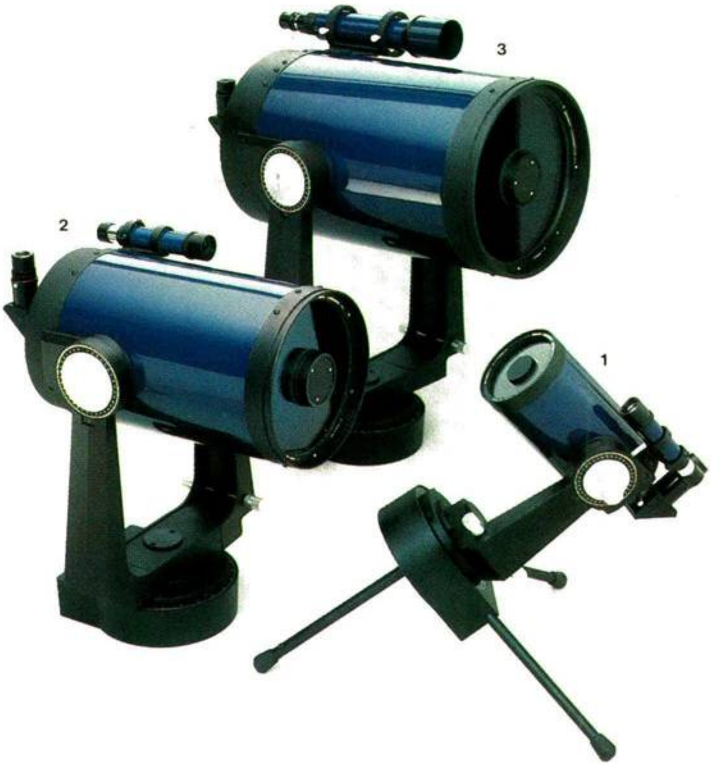
ICD# 08070 71574

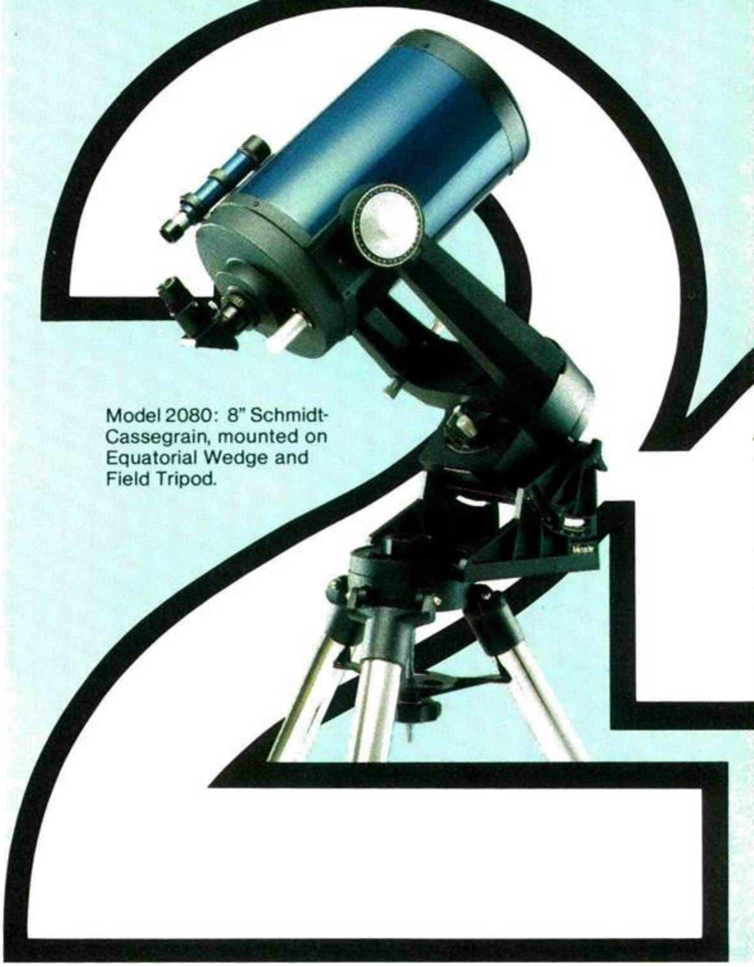


Galaxy NGC - 4565

0 08070
08

Meade Schmidt-Cassegrain Telescopes: **(1)** 4" Model 2044, with standard-equipment table tripod; **(2)** 8" Model 2080; **(3)** 10" Model 2120.





Model 2080: 8" Schmidt-Cassegrain, mounted on Equatorial Wedge and Field Tripod.

TELESCOP ARE MADE

Some telescope manufacturers make Schmidt-Cassegrains; others make reflecting telescopes; still others make large-aperture deep-sky telescopes. **But only Meade Instruments makes them all—more than 24 different models,** from the ultraportable Model 2044 4" Schmidt-Cassegrain to the incredible Meade DS-16 16" f/4.5 Deep-Space Telescope. **Plus more than 250 accessories** for virtually any observing or astrophotographic requirement. Whether you're a beginning or advanced amateur astronomer, Meade Instruments has a telescope that's right for you and your budget.

Call or visit your Meade dealer today, and see why Meade Instruments is the World's leading manufacturer of precision, diffraction-limited astronomical instruments for the serious amateur. There are over 275 Meade dealers in the U.S.A. and Canada, and more than 500 Meade dealers worldwide. Phone us toll-free for the location of your nearest dealer.

Meade 4", 8", and 10" Schmidt-Cassegrains have, since their inception, led the industry in high-performance design, features, and instrumented appearance. Meade Schmidt-Cassegrains were the first in their aperture class to include precision worm-gear drives as standard equipment; the first to incorporate computer-optimized internal baffles and optical designs; and the first to be offered with a Lifetime Warranty. For the most advanced photographic applications, the Meade 8" Model 2080/LX and 10" Model 2120 include the ultraprecision LX ("Long Exposure") Worm-Gear Drive System, with 10 arc-second tracking tolerance. And **all** Meade Schmidt-Cassegrains include the finest, laser-tested optics available from any manufacturer. Before you buy a Schmidt-Cassegrain, see, test, and compare the Meade 4", 8", and 10" models. We know you'll be glad you did.

Enhanced Mirror Coatings Group Now Available!

Meade 8" and 10" Schmidt-Cassegrains are now optionally available with an enhanced aluminum coating on the primary mirror and silver coating on the secondary mirror, resulting in a net increase in image brightness of about ***12%*** *over standard aluminum coatings. See your Meade dealer for full details!*

Meade 8" Model 2080 Photo

Meade 35mm Astrophoto Slide Sets

Meade 35mm astro slides include a wide range of fantastic deep-space, solar, lunar, and planetary photos, taken through stock Meade 4", 8", and 10" Schmidt-Cassegrains. Set #1 includes 20 color slides; Set #2 includes 20 high-resolution black-and-white slides. No two slides are the same. Available directly from Meade Instruments at $15.00 per set, postpaid anywhere in the World, or see your Meade dealer.

AUTHORIZED INTERNATIONAL DISTRIBUTORS

Australia
Science World
138 Railway Parade
Leederville, 6007,
Perth, Western Australia

Belgium, Netherlands
O.P.-Slotte
Chaussée D'Alsemberg 59
1060 Brussels, Belgium

Denmark
Astro Mekanik
Bernstorffsgade 32
9000 Aalborg, Denmark

Italy
Ottica F.lli Miotti
Piazza Grandi No. 2
20129 Milan, Italy

France
Devaux Chevet S.A.
35, Rue de Rivoli
75004 Paris, France

Medas S.A.
57, Avenue Prés. Doumer
B.P. 181
03206 Vichy, France

Japan, Korea
MIC International Corp.
Hoshino Bldg.
7-20, Toranomon, 3-chome
Minato-ku, Tokyo, 105 Japan

Portugal
Contabilex
Av. 25 de Abril, 13-1°
2750 Cascais, Portugal

Spain
IMVO/R, Roure Codoñer
C/Col. Legi n. 24 (Bordeta)
Lleida, Spain

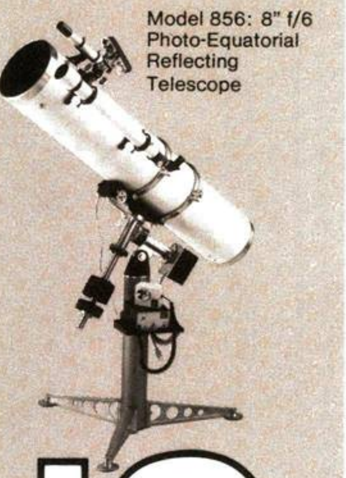
Sweden
AB G Wendelholm
Box 14069 S- 10440
Stockholm, Sweden

Switzerland
E. Aeppli/Spiegeloptiken
Loowiesenstrasse 60
CH-8106 Adlikon
Switzerland

West Germany, Austria
Kosmos Service
Postfach 640, Pfizerstrasse 5-7
7000 Stuttgart 1, West Germany

Model 97D: 90mm (3.5")
Maksutov Spotting Scope
with 5x24mm Viewfinder.

Meade DS-16 16" f/4.5
Deep-Space Telescope,
with photo options.



Model 856: 8" f/6
Photo-Equatorial
Reflecting
Telescope

4 PLUS

Model 90B:
1000mm f/11
Maksutov Telephoto

Accessories

PE MODELS BY MEADE

Meade 10" and 16" Deep-Space Telescopes have revolutionized the serious amateur's exploration of deep-space objects, both visually and photographically – and at extremely modest cost considering the apertures involved. By combining giant, diffraction-limited apertures with fast f/4.5 photographic focal ratios, the Meade DS-10 and DS-16 permit the capture on film of amazing nebular and galactic detail in 5-to-15 minute exposures. Visually, observe blue-green colorations in the Orion Nebula (M42); inspect dust lanes in spiral galaxies M51 and M101; resolve the core of the Hercules globular cluster (M13). And, with their precision-machined equatorial mounts and available electric motor drives, the Meade DS-10 and DS-16 let you spend your time **observing,** not **tracking.**

Meade 6", 8", 10", and 12½" Reflecting Telescopes permit an extremely wide range of astronomical applications, whether lunar, planetary, or deep-space. Thousands of these high-performance, diffraction-limited Meade reflecting telescopes are now in use throughout the World. Each model is supplied complete with equatorial mount, electric motor drive, setting circles, viewfinder, 2 fully-coated eyepieces, and the finest 1/10-wave optical surfaces. The large assortment of optionally available Meade photo-visual accessories yields an almost unlimited growth potential for the motivated observer.

Meade Research-Quality Accessories and Telescope Parts are available for use with almost every telescope type and brand. commercial or homebuilt, and for just about any photographic or visual observing requirement you might have in mind. Accessories and parts available include eyepieces in over 2 dozen optical designs, focal lengths, and barrel diameters; the World's finest fixed- and variable-power Barlow lenses; photo-visual color filters; nebular filters; rack-and-pinion focusers; illuminated reticle guiding eyepieces: viewfinders of 30mm, 50mm, and 60mm apertures; camera adapter systems; photo-guide telescopes; variable-frequency drive correctors; off-axis guiders; rotary eyepiece holders. Details on these and many, many other Meade telescope accessories and parts are contained in the Meade General Catalog.

Meade 1000mm f/11 Maksutov-Cassegrain Telephoto Lenses and Spotting Scopes. Read Herbert Keppler's test report in the Jan., 1984, issue of *Modern Photography:* The Meade Model 90B is "compact, beautifully made...indicates a clear understanding [of] what is needed from a telescope maker for photography...well-made and finished, [yet] moderately priced...a highly convenient 1000mm lens—probably the most convenient I have worked with...Equally amazing is the lens's ability to focus as close as 10 ft....and it's pure delight to read "Made in U.S.A." on the front ring..." We thank Mr. Keppler for his gracious remarks, and we know that one look will convince you too.

U. S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A. (except Calif.):

1-800-854-7485

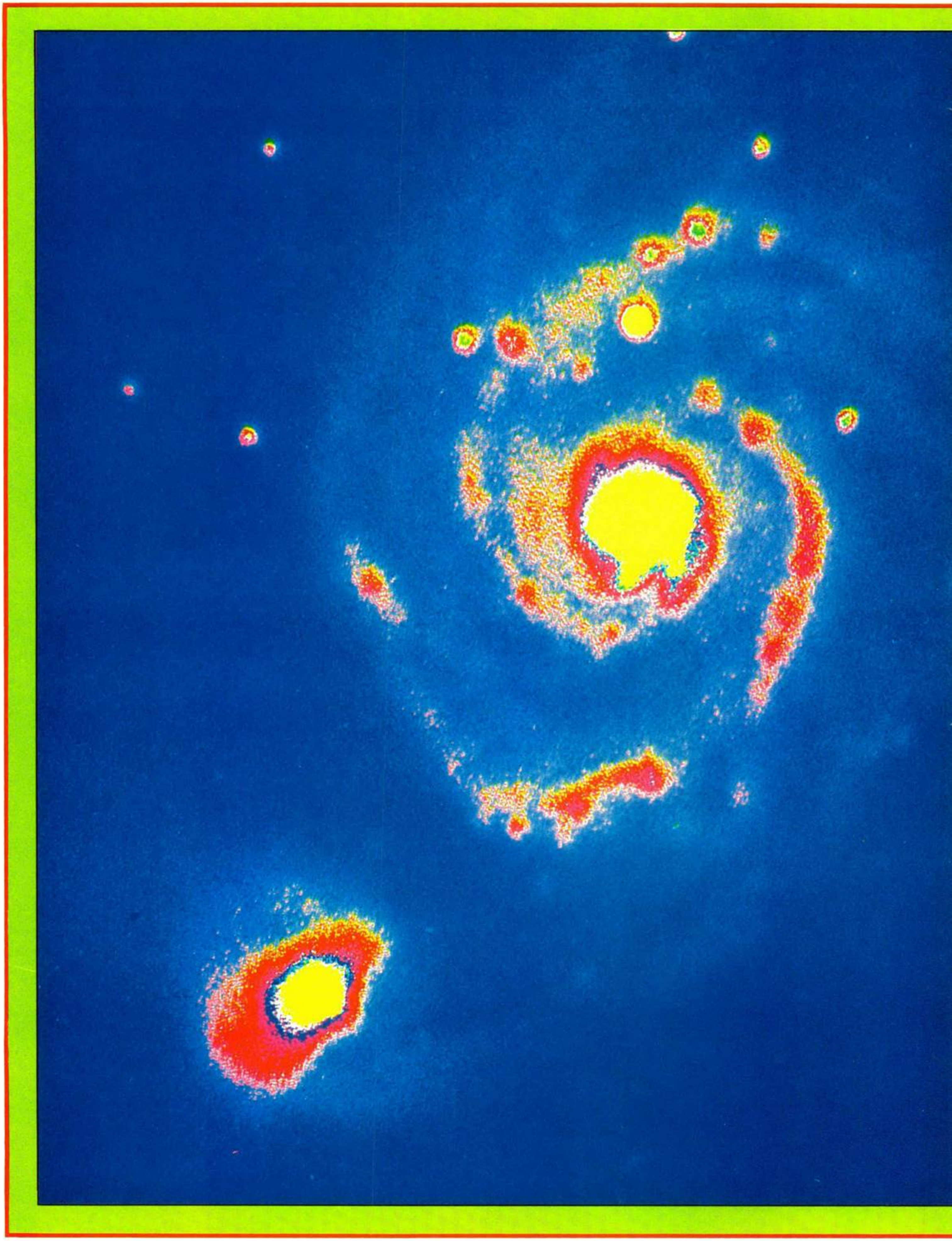
From all other areas, including California, dial direct: **(714) 556-2291**

Complete 52-Page General Catalog – $3.00

Send $3.00 for your copy of the Meade full-color **General Catalog #84C,** with many astrophotos through Meade telescopes and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

Meade Instruments Corporation

1675 Toronto Way, Costa Mesa, Calif. 92626 □ (714) 556-2291

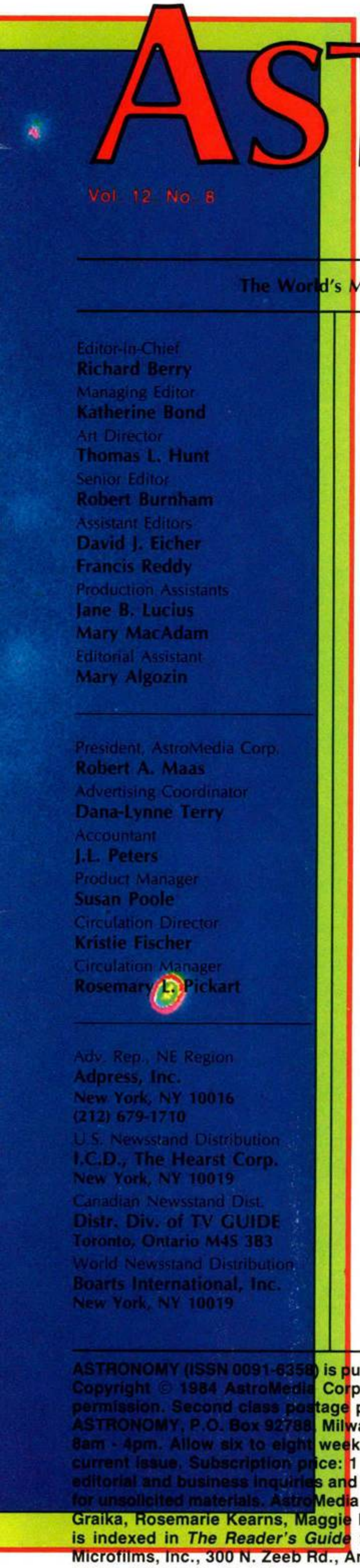


ASTRONOMY

Vol. 12 No. 8

August 1984

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther



Editor-in-Chief
Richard Berry
Managing Editor
Katherine Bond
Art Director
Thomas L. Hunt
Senior Editor
Robert Burnham
Assistant Editors
David J. Eicher
Francis Reddy
Production Assistants
Jane B. Lucius
Mary MacAdam
Editorial Assistant
Mary Algozin

President, AstroMedia Corp.
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Accountant
J.L. Peters
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Adv. Rep., NE Region
Adpress, Inc.
New York, NY 10016
(212) 679-1710
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
New York, NY 10019
Canadian Newsstand Dist.
Distr. Div. of TV GUIDE
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
New York, NY 10019

6 **Astronomical Ballooning**
by Sten Odenwald

16 **Spectral Visions, Part 1: The Long Wavelengths**
by David J. Darling

Forum 24 **Hit and Run . . . A Talk with Walter Cunningham**

In Focus 32

Behind the Scenes 33

Photography in Astronomy 35 **Isophote Mapping**
by Joseph Macrie

Astronomy Reviews 39

Eye on the Sky 42 **Moon Diminishes Perseids**
by Fred Schaaf

Gazer's Gazette 51 **Observing the Sun**
by Robert Burnham

AstroNews 58

AstroCalendar 62

AstroMart 64

Stellar Frontiers 66 **A Star That Has Risen from the Dead**
by Sun Kwok

Equipment Atlas 74 **The Coming of Epoch 2000**
by Earle F. Dodds

The Backyard Astronomer 78 **Sagittarius**

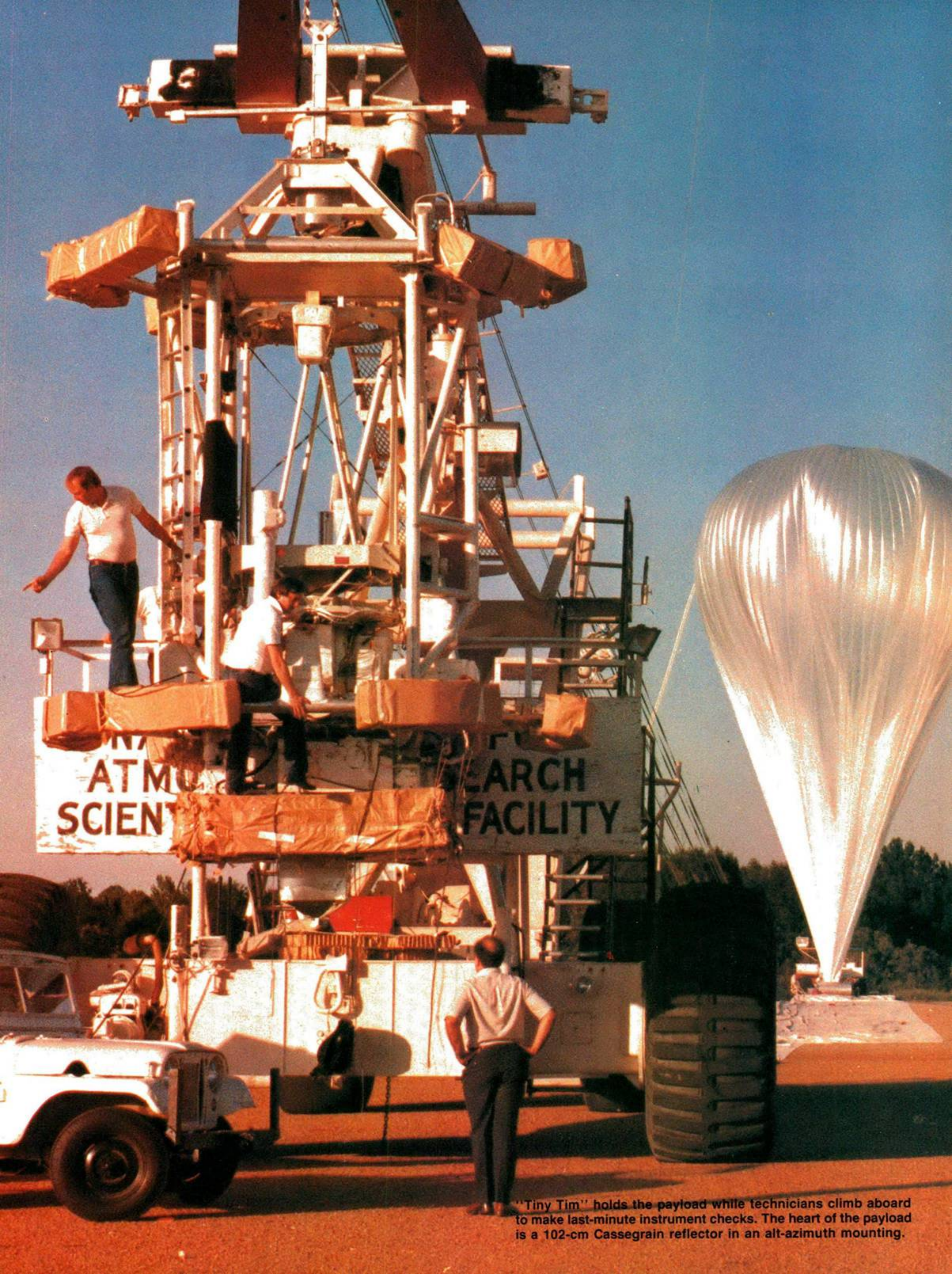
Cover: The spiral galaxy NGC-4565 in Coma Berenices, photographed by Joseph Macrie. This month, ASTRONOMY takes you on a balloon ride to see how some professional astronomers gather data. We then examine the universe in the "long wavelengths," the radio and infrared regions of the spectrum. We also explore isophote mapping, the powerful photographic technique that created the beautiful images here and on our cover. These pages: M-51, the Whirlpool Galaxy, also photographed by Macrie.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202. **Copyright © 1984 AstroMedia Corp., all rights reserved. Material in this publication may not be reproduced in any form without permission.** **Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: (414) 276-8547 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. AstroMedia staff: Patricia Adams, Jacquelyn Berger, Tony Cunning, Merlene Edwards, Wendy Graika, Rosemarie Kearns, Maggie Martinez, Sherrie Miller, Susan Robinson, Deborah Wicentowski. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.**

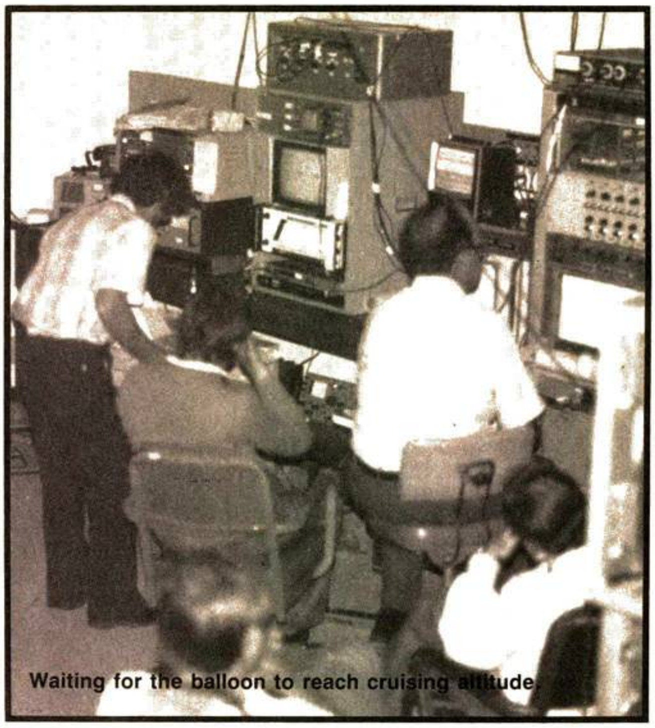
ASTRONOMICAL BALLOONING

by Sten Odenwald

Shortly after sunset, this helium-filled balloon will ascend into the stratosphere, carrying with it a special infrared telescope. All photographs by the author.


NA
ATMO
SCIEN
F
EARCH
FACILITY

''Tiny Tim'' holds the payload while technicians climb aboard to make last-minute instrument checks. The heart of the payload is a 102-cm Cassegrain reflector in an alt-azimuth mounting.



Waiting for the balloon to reach cruising altitude.

ASTRONOMICAL BALLOONING

Five years ago, when I first joined the infrared astronomy program run by the Harvard-Smithsonian Center for Astrophysics and the University of Arizona, I had no firsthand experience with ballooning — of any kind — and only the vaguest notion of how it was done.

This state of ignorance remained unchanged until I traveled to a quiet town in eastern Texas called Palestine (pop. 15,948). A casual glance at this community wouldn't show it to be much different in geography or temperament from its neighbors. But between May and October, the prime months for scientific ballooning, the situation changes radically. You might then hear the motel and restaurants echoing with talk of scintillation counters, bolometers, cryogenics, and ground loops — all spoken in crisp tones, very different from the leisurely east-Texas inflections of the natives. The center of this scientific activity is a small group of buildings just off Route 287, outside of Palestine. These form the National Scientific Balloon Facility — dubbed by common usage "the balloon base." This is where some 61 engineers, technicians, secretaries, and administrators oversee the needs of scientists who come from all parts of the world.

My first impression of the base was of a low-key, almost relaxed, operation; the real drama, it turned out, occurs only during those two or three times a week that a launch is in progress. The rest of the time the scientists are busy working to get their instruments ready while the support staff deals with the details of maintaining and operating the base.

Why do we infrared astronomers use balloons? Very simply, we need to place our instruments as high as possible to eliminate the screening effects of water vapor in the Earth's atmosphere. To achieve this, some infrared astronomers work at observatories on very high mountaintops. Others have turned a C-141 jet into the "Kuiper Airborne Observatory," which flies sensitive infrared detectors at altitudes of nearly eight miles. (See "KAO: Mission Incredible," ASTRONOMY, June 1980.) Going to the ultimate, one multi-national team of infrared astronomers launched a satellite — IRAS — that worked in space, unhindered by any atmosphere at all. (See "IRAS and the Infrared Universe," ASTRONOMY, March 1984.)

Now, given that these research methods and institutions already exist, why bother with balloons? The answer really comes down to matters of logistics, funding, and opportunity. High-altitude observatories work well, but pose constraints on the observer (severe cold and too little oxygen for comfort), and the available observing time is booked up long in advance. Besides, uncooperative weather keeps them shut down part of the time. The Kuiper Airborne Observatory is better in some ways, but it is just one aircraft and its programs are also heavily scheduled. IRAS was the most wonderful yet — and the coming generation of infrared satellites will also be great — but such satellites are extremely expensive, have very long lead times in development, and are essentially "one shot" items. In addition, not every infrared astronomer can be on the team that gets to use it most of the time.

When you look at the situation this way, ballooning begins to make a lot of sense! Offering another avenue to do infrared astronomy, ballooning is relatively cheap; moreover, the instruments flown can be improved as fast as the technology improves, and the cycle time for making a flight, reducing the data, and preparing for a new flight is short enough that you can make several flights a year.

The Telescope and Detectors

Our far-infrared instruments are similar to those of optical astronomers: we have a 102-cm (40-inch), f/13.7 Cassegrain reflector in an altitude-azimuth mounting — the largest far-infrared telescope used this way in the world. Made of an aluminum alloy called Tenzalloy, the mirror is about eight inches thick at the center but only half an inch thick at the edge. The surface is nickel-coated and figured to a sphere. To point and aim a telescope that is dangling from a balloon on the end of a cable might sound like a formidable task. Besides the balloon's own random motions, the Earth's rotation will make a star drift out of the eyepiece field unless the telescope is driven mechanically to keep up. We solved this problem by using gyroscopes to define an "inertial space" that remains fixed relative to the stars — and thus automatically suppresses the effects of star field motion. We can then employ small motors to re-aim the telescope here and there toward the celestial sources we wish to examine.

To see exactly where the scope is pointing, we strap to it a wide-field TV camera and a 35mm film camera to photograph the region of the sky where our telescope is aimed. As a check, we usually observe a bright planet like Mars, which is a very strong infrared source. This provides information about where the detectors are pointing and calibrates their sensitivity to a known source of radiation. The telescope normally operates in either a "raster" (scanning) or a "point-and-integrate" mode. The former has been a workhorse for the past decade; with it we can map an area of sky four times larger than the Full Moon in as little as 20 minutes. When we point-and-integrate, the detectors can see objects 10 to 20 times fainter since they stare at a single part of the sky for a long time, collecting more radiation.

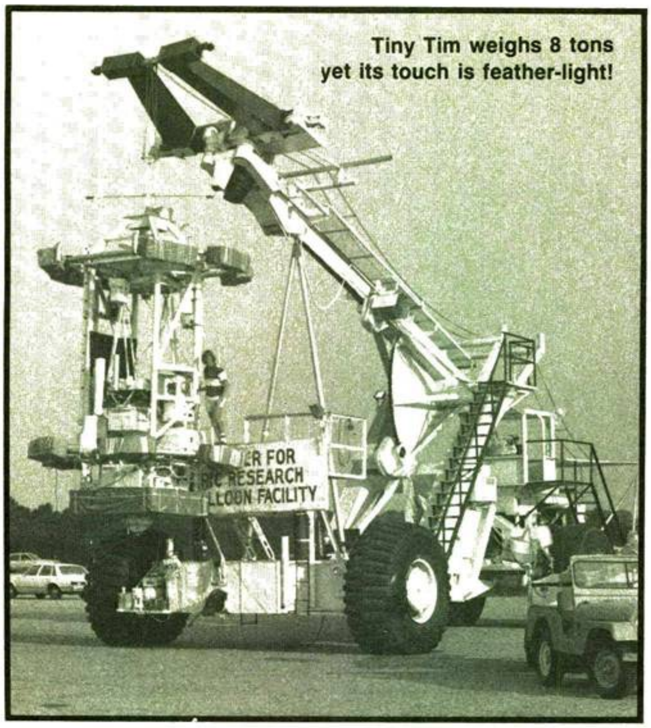
Because the instruments must operate unmanned and far from reach — 95,000-foot altitudes are usual on a typical flight — we oversee the telescope's operation by a combination of stored commands and updates radioed from the ground. All the instructions sent to the payload are transmitted uplink to a device called a command decoder that communicates with the other electrical subsystems onboard. It activates motors, changes the pointing direction, turns on amplifiers, and so on. The digitized data sent downlink are recorded on magnetic tape. In addition, we have readouts of particular functions, such as the battery current, displayed during the flight on strip-chart recorders. This lets us monitor how things are going. During a typical eight hour flight we gather over 1.2 billion bits of data — roughly the contents of an entire 24-volume set of the *Encyclopedia Britannica*. On the average, the data fill twenty 2500-foot magnetic tapes.

The detectors form the heart of the system — or more properly, its retina. They are usually chips of a special material that changes its resistance depending on how warm it becomes under the flow of incoming radiation. We send a current through the detector material and the varying resistance produces a change in the voltage which, when amplified thousands of times, can tell us how bright the object is. Since infrared sources are very weak, the detector itself must be as cold as possible so it won't contribute "noise" to the system. This means placing it inside a large vacuum flask — a giant Thermos bottle — and bathing it in 1.8° K liquid helium. The detectors are so sensitive that after a minute of staring at a particular part of the sky they can detect an energy flow of as little as 10^{-14} watts per square meter. This is equivalent to seeing the heat given off by a person sitting on a snow bank from a distance of nearly 40 miles! Translating this into astronomical terms, it means we can see the most luminous, dust-obscured stars in dense molecular clouds anywhere in the Milky Way Galaxy.

Launch Day

After three weeks of troubleshooting the finicky electronics and double-checking the telemetry to make sure there's no electrical interference, we have the payload more or less buttoned up and ready for flight. The meteorologist at the 11:00 a.m. briefing has told us that the weather looks promising; the surface winds will be about 3 mph at launch this evening and the sky is clear at the balloon base and at the recovery site. Tonight, the track that the balloon is expected to take will be a gentle arc from here to somewhere near Lubbock, Texas, 250 miles to the northwest. The launch vehicle — "Tiny Tim" — a 10-ton diesel-powered behemoth with wheels eight feet tall, picks up our gondola at 1 p.m. and drives the half mile to the launch pad at the pace of a brisk walk. After one last check-out on the launch pad, the balloon is brought out as well.

Evening approaches. One hour before launch, the checkout is complete and the balloon and parachute have been carefully unfolded. Although it weighs two tons, the balloon is exquisitely delicate. Made entirely of tough thin plastic, it supports the two-ton weight of the payload on nylon straps, or gores. Yet the balloon material is so fragile that if human fingers were to apply too much pressure when it is unfolded, a tear would start that would shred the entire balloon once it was inflated and the full weight of the payload bore down on it. In seconds the balloon would dissolve into an undulating sea of plastic covering



Tiny Tim weighs 8 tons yet its touch is feather-light!

ASTRONOMICAL BALLOONING

"There's No Such Thing As a Free Lunch"

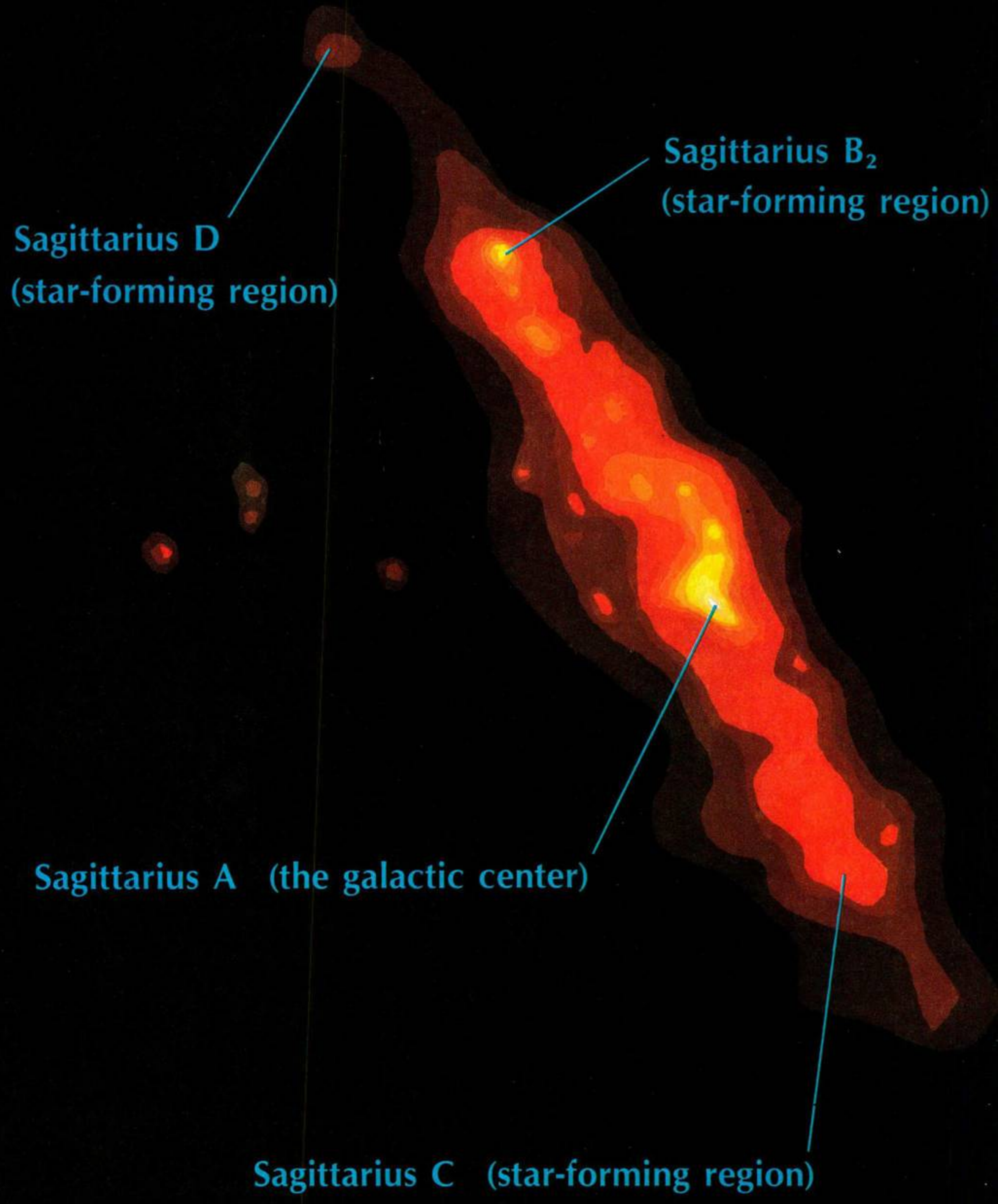
As you might imagine, astronomical research is an expensive undertaking. Our payload was designed and assembled by engineers at the Center for Astrophysics between 1971 and 1973 using in-house research and development funds. Since then, we have obtained $100,000 on a yearly basis to maintain, upgrade, and launch the payload and to pay the salaries of the scientists and engineers. A typical observing campaign in Palestine can cost $20,000 for the balloon, $10,000 for the helium to fill it, and between $10,000 and $15,000 for food, lodging, and transportation for the 10 scientists and engineers during a typical three-week observing session.

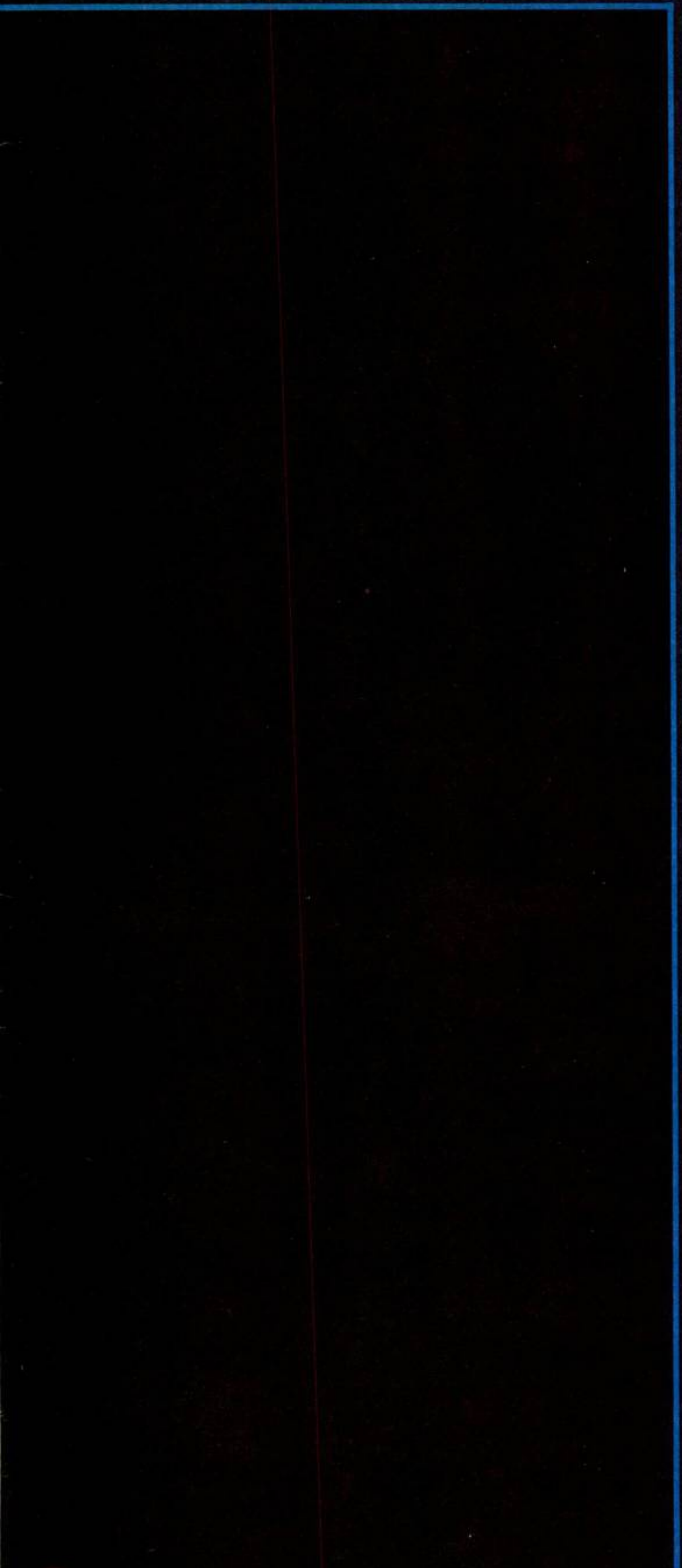
The detectors themselves, which change every few flights, are maintained by separate funds provided by the scientists concerned or by a NASA research grant. A detector chip, its amplifiers, and cryogenic vacuum flask can cost between $4,000 and $10,000 for a simple one-element bolometer system to as much as $500,000 for a two-band far-infrared spectrometer. The money is obtained through a formal research proposal submitted to NASA during the year prior to the intended year of the observing campaign.

In the face of the recent IRAS successes, our group will have to re-evaluate its goals and strike out in new directions. Since our program began in the infant years of infrared astronomy, the field has changed markedly — and so have the areas of productive research. Although our telescope will continue to have the advantage of high angular resolution, the next generation of experiments must do much more than this.

The balloon is deliberately under-inflated at launch, leaving room for the helium to expand as the balloon rises.

The Infrared Heart of the Milky Way


Sagittarius B_2 (star-forming region)
Sagittarius D (star-forming region)
Sagittarius A (the galactic center)
Sagittarius C (star-forming region)



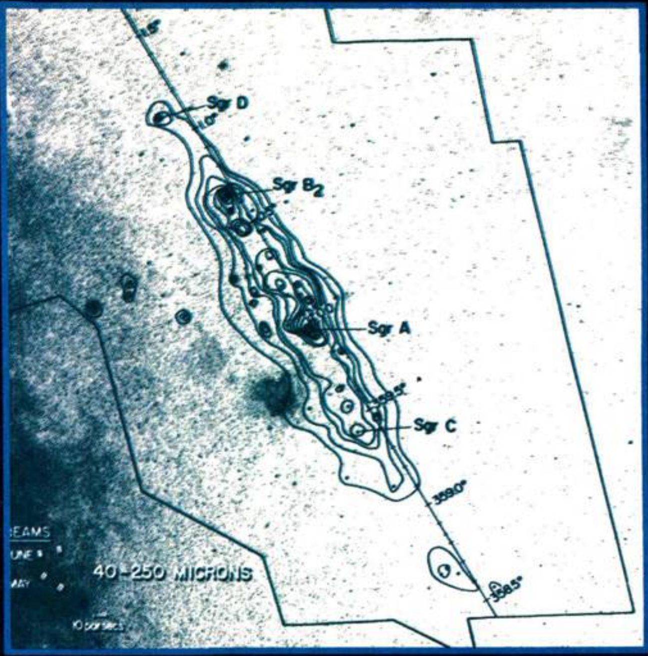


photo courtesy of the author

The center of the Milky Way Galaxy is hidden from view at optical wavelengths by thousands of light-years of dust and gas. But as we shift our sensitivity toward longer and longer wavelengths, the fog begins to lift. In the far-infrared, at 40 to 250 micrometers, the view is essentially transparent.

The map at left was compiled from far-infrared data taken on balloon flights almost a decade ago. As you can see, the region of emission lies most strongly along a line that corresponds to the galactic equator. The brightest knot marks the location of Sagittarius A, the galactic center itself (see also the section on Sagittarius in Backyard Astronomer, page 78).

Though it appears linear, the emission is actually coming from a flat disk of dusty gas about 300 parsecs in diameter, which we are seeing edge-on. This disk has a temperature of about 70° K and has been heated by the radiation of many hot, young O-type stars. Work by other astronomers has shown that many clouds of molecular material such as carbon monoxide surround this disk. These clouds may have been driven out of the central regions by the core's fierce radiation. The bright knots represent regions of ongoing star formation; to understand the scale of activity, bear in mind that each of these regions is intrinsically thousands of times brighter than the Orion Nebula!

The dim regions of emission at far left are probably smaller nebulae — about the size of M-8 or M-20 — which happen to lie nearer to us and are seen in projection. They are star-forming regions, too, but on a much more reduced scale.

Launch requires a calm, still evening. Flights often reach 90,000 feet or higher and last all night.

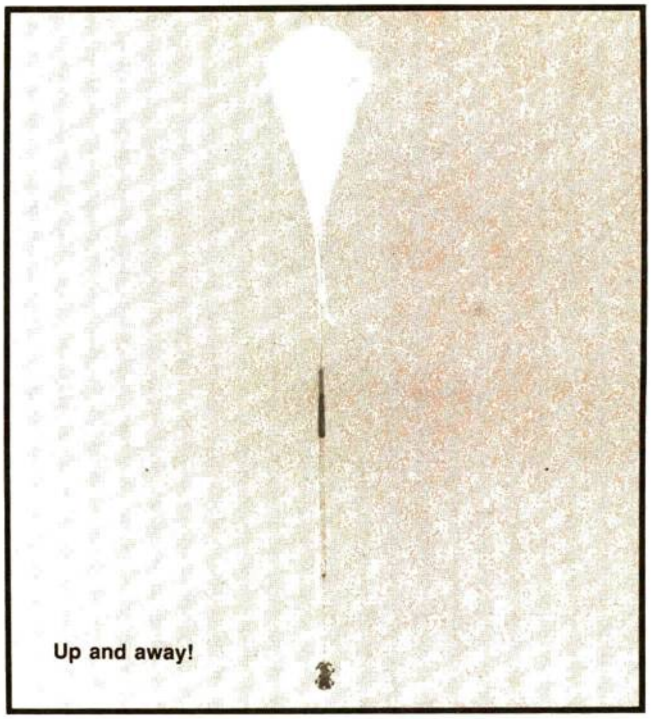
an area the size of a football field.

Just before launch, two men carrying plastic hoses from the helium truck begin to inflate the balloon through tubes attached to the top of it. While they work, the upper third of the balloon is held securely by a tie-down vehicle. Inflation usually takes about 45 minutes; the sound you hear as the helium gas races out of the tank truck into the balloon is like a small jet revving up for takeoff. When the balloon is filled as much as needed, the roar ceases, the two men tie off the filling tubes with a few simple overhand knots, and back away. The still captive balloon now towers over 100 feet above their heads. There is complete silence. The balloon sways gently in the twilight, everyone crosses his fingers, and when all is clear, the tie-down vehicle releases the balloon.

It rises, fluttering almost noiselessly in the gentle wind, and ascends quickly until it is almost directly above the payload, still held by Tiny Tim. With amazing speed and agility, Tiny Tim then moves to place the payload directly under the rising balloon and then releases it as the support cable becomes taut. The dangling payload swings to and fro like a giant pendulum and slowly disappears up into the darkening night sky. It shines briefly like a bright star as it rises out of the evening sky into the rays of the setting Sun. Members of the launch crew return to their homes to have dinner, play with their children, and watch TV while the scientists and tracking crew remain behind. Their day has just begun.

What follows next is a two-hour lull, during which the balloon continues to ascend until it reaches its appointed float altitude, some 95,000 feet above the Texas plains. At this altitude, the atmosphere provides 100 times less pressure than at sea level and the temperature is a nippy −90°F. It's so cold up there that we actually have to heat some of our equipment to get it to work at all! When we reach "float," the telescope is unstowed and we move to look at the first object on our schedule — hopefully a planet, for that all-important calibration.

The schedule is planned well in advance. Unlike the romantic image of scientists who accidentally discover some new magic substance or a new star in the sky, astronomers embark on premeditated journeys of exploration. To a large degree, we need to have a clear idea of what we hope to find before we can build instruments to look for it. The sky is much too vast for us to waste our limited time on regions that will not bear the kind of fruit we seek. Serendipitous discoveries do happen, but the nature of research tends to work against them. So we look at parts of the sky like the Milky Way, where we know star-forming regions are found in great abundance. We look into places that the radio astronomers have told us are filled with hot molecular gas. We look at nearby galaxies known from optical studies to be dusty and luminous. And if we are lucky, we will see something that no one has ever seen before — or may not have seen clearly enough to understand.



Up and away!

ASTRONOMICAL BALLOONING

As the night unfolds and we step through our list of 10 to 15 targets, we see how each one differs from the others. Some are just single diffuse blobs of invisible warm dust that our sensitive detectors say is suspended between the stars we see on our TV screen. Others may show individual hot spots scattered over an area as large as the Full Moon. We watch the squiggles of the strip chart pens as they rise to announce some new enigma and fall to tell us there's nothing more to be seen. Sometimes, just when we think there are no more new sources to be found in a raster scan through a region, the pens move suggestively once again. A mixture of excitement and pain accompanies our realization that we must move on to the next target, a move we have already delayed twice in the last five minutes.

After 8 to 10 hours of observing, we have accumulated 20 magnetic tapes of data. On command, the payload is chopped free of its support cable, and its parachute unfolds to brake its descent. Folklore at the balloon center is replete with gleefully told stories of payloads that have landed in lakes, dense forests, the backyards of expensive homes, or the alligator-infested swamps of Louisiana. You also hear how some rural farmers have actually shot at balloons and their fragile payloads — no doubt thinking that they were sent by aliens from outer space. But in spite of the many hazards, natural and manmade, our payload has always made it back in one piece, ready for the next launch.

Recovering the flight film from the star-field camera completes the data taking of a successful flight. After we pack up the flight control electronics and mothball the gondola until next time, we return to our respective academic institutions to pore over the scientific data, make our maps, and write up our discoveries for publication in the technical journals. Then, as spring rolls again toward summer, our thoughts turn once more toward Palestine — and another season of ballooning with a new set of targets.

Sten Odenwald is an infrared astronomer currently at the Naval Research Laboratory in Washington, D.C. His research interests include studies of the far-infrared properties of giant molecular clouds and young star-forming regions in the Galaxy. His last article for ASTRONOMY *was "The Planck Era," which appeared in the March 1984 issue.*

Spectral Visions, Part 1
The Long Wavelengths

by
David J. Darling

Radio

Astronomical Source: Electrons in Magnetic Fields

30 kilohertz
10,000 m

No one on this planet has traveled more than a quarter of a million miles from home, yet we're fairly certain that at the center of the Crab Nebula, a star-wreck 36,000 trillion miles away, there's an object so dense that a tear-sized drop of it would weigh more than 30 million tons. Our most distant spacecraft is barely beyond Neptune's orbit, yet we've glimpsed the dulling glow of creation and begun to reconstruct events to within one ten-million-trillion-trillion-trillionth of a second of the Big Bang itself. How is this possible? How can we know so much about the universe at large when we've scarcely ventured from the surface of our own world?

We're continuously bathed in information from every corner of space. We're a node in a vast network of data channels linking us with every object in the cosmos. And the medium of these channels? It can be vibrating electric and magnetic fields — *electromagnetic (EM) radiation* — of which visible light is the most familiar example. It may be fast-moving atomic nuclei and electrons, the high-energy bullets that comprise *cosmic rays*. Or perhaps it's will-o'-the-wisp *neutrinos* or *gravity waves*. All the secrets of space and time are carried by these unlikely cosmic couriers — the only limit lies in our ability to detect, decode, and interpret them. We'll discuss the prospects for cosmic-ray, neutrino, and gravity-wave observations later. But first, let's focus on our prime source of astronomical information, EM radiation — easily the most potent source of data in the universe today.

Virtually everything in space broadcasts EM signals — planets, stars, galaxies, even regions occupied only by thin clouds of gas and dust. Physical properties like density, temperature, magnetic field strength, chemical composition, and so on, are coded in the EM radiation an object emits. Through continued observation, we can construct an amazingly detailed picture of how an EM source might appear up close.

But first there's the problem of detection. Cosmic sources can be very weak, and Earth's atmosphere is a complex EM filter. We actually need a variety of detection equipment, both above and below the atmosphere, just to sample all of the radiation coming from a single source.

In addition to visible light, EM radiation manifests itself as *radio waves, infrared* and *ultraviolet* radiation, *X-rays*, and *gamma rays*. The complete EM spectrum stretches from wavelengths of less than one ten-trillionth of a centimeter to several hundred kilometers. This great bandwidth means that we need a battery of detection equipment to cover the complete spectrum. At one extreme, we may be dealing with radio waves longer than a freight train; at the other, we may confront gamma rays with wavelengths smaller than an atomic nucleus. In some cases, we may find virtually the full range of EM activity in a single cosmic source.

We must also consider the effect of Earth's atmosphere. Only radio waves (those with wavelengths in the millimeter to 15-meter range), some patches of infrared, and visible light manage to reach the surface. Radiation of other wavelengths is reflected or absorbed at higher levels. Until half a century ago, we were restricted to the "optical window," the tiny slit in the EM spectrum, from 0.3 to 0.7 micrometer, to which our eyes respond. Astronomy thus became heavily biased toward the optical wavelengths because of these atmospheric and biological filters.

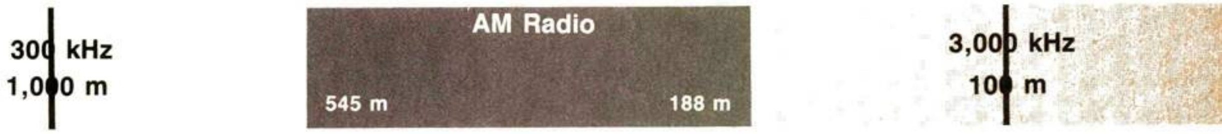
Today, our cosmic horizons are broad. At ground level, we've probed the radio waves and infrared. From balloons, sounding rockets, and satellites, we've examined the short-wavelength domains — ultraviolet, X-ray, and gamma-ray — and, again, the infrared. But we still retain a special regard for visible light. Because of our unique make-up, we continue to look to optical observation as a base for understanding new results.

Exploring the Visible

In the beginning, there was the human eye. Then, in the early 17th century, came the telescope, which grew larger through the years, boosting our ability to probe deep space. In the late 19th century, the ability of large telescopes to gather light was teamed with the ability of photography to store it. Even very faint objects were now accessible to examination, their feeble glow built up through long exposure on light-sensitive photographic plates.

There was still another important astronomical development in the 19th century — the spectroscope. Harnessed to a telescope, this device gave us access to the vast stores of data hidden in a ray of light. Astronomers took photographs of countless spectra, and the science of astro*physics* was born. Our knowledge of the universe became more refined.

Today, telescopes continue to be enhanced by the



latest technologies. Photography itself, however, has a major drawback. Its sensitivity isn't great, and background light from the surrounding sky limits the exposure time for building up images. So we bring in other techniques, drawn from the technologies of television and the amplification of electronic images. In highly sensitive photomultiplier tubes, for instance, individual photons of light strike a special material, knock electrons off its atoms, and create an electric current. But photomultiplier tubes also have a problem — they can image only a small area of sky at a time and so quickly use up valuable telescope time.

Another technique has been introduced for imaging larger regions. Charge-Coupled Devices, or CCDs, now combine the sensitivity of photomultipliers with the large-area, light-storage power of photography. A CCD can respond to two-thirds of all the photons that strike it, gathering the same information as a several-hour-long plate exposure in just a few minutes.

What of the telescopes themselves? All modern instruments are basically reflectors, using a parabolic mirror to gather and focus light. But increasing size and cost have prompted us to come up with new, imaginative designs. One of the most promising makes use of a cooperative array of mirrors. The Multiple Mirror Telescope on Mt. Hopkins, the first of this kind, incorporates six 1.8-meter mirrors that work in unison to achieve a single image. Its chief advantage is cost: six 1.8-meter mirrors are cheaper to make than a single equivalent mirror of 4.5 meters.

The largest telescopes have primary mirrors well over three meters in diameter, and there are at least 11 of these if we include those used for infrared work. But why build ever larger ground-based instruments? To increase *light-gathering power*, the ability to detect very faint objects. There's an urgent need for optical astronomers to provide more information on recently discovered, very faint objects that have been found to be strong sources of radio or X-ray emission. Various plans exist for new, larger telescopes — bigger MMTs, bigger single-mirror instruments, and revolutionary designs involving multi-faceted surfaces.

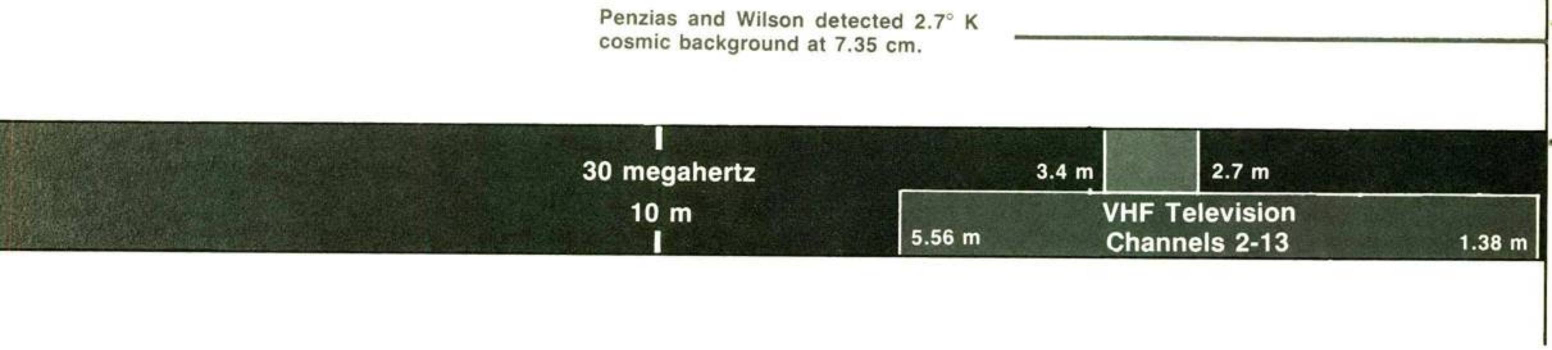
The other major property of a telescope, its *resolving power*, is limited for large instruments at optical wavelengths by fluctuations in the atmosphere. In fact, for all optical telescopes greater than 20 centimeters — the size of medium-sized amateur scopes — the atmosphere restricts resolving power to about one-half second of arc.

For this reason, in addition to larger ground-based instruments, we'd like to place some optical telescopes where the "seeing" is perfect — out beyond Earth's shifting atmosphere. Inch for inch, pound for pound, ground-based instruments work out far cheaper. But the scientific potential for optical observation beyond the atmosphere is tremendous. The Space Telescope, scheduled for launch by the Space Shuttle in late 1986, will be able to detect objects at least 50 times fainter than those within the grasp of large ground-based instruments. At 2.4 meters, its aperture is less than that of the 3.0-meter Large Space Telescope originally planned, but astronomers are more than content. Perched in its 500-kilometer-high orbit, it will increase by an estimated 350 times the volume of the observable universe.

We've said that the cosmic view at visible wavelengths is rather special to us. But we realize now that it could never provide a complete picture of the cosmos. Some phenomena of vital significance only appear at wavelengths far outside the visible region. And others, although they may be detectable optically, reveal their true character only in the radio, X-ray, or other "invisible" regions of the spectrum. We'll consider the appearance of the universe at the short wavelengths — the ultraviolet, X-ray, and gamma-ray portion of the spectrum — next month, in Part 2. For the moment, however, let's look at what processes cause cosmic objects to emit light, and what we can hope to learn from observations made at visible wavelengths.

Most things in the universe that give off light do so by *thermal* processes — that is, because they are hot. In fact, every piece of matter in the universe gives off at least some radiation. If an object is cool — like a planet — it will emit its thermal radiation mostly as radio waves or infrared. If it's hotter — like the average star — it will emit visible light. And, if it's very hot indeed, it may emit copious ultraviolet or X-ray radiation.

Although thermal sources broadcast at a range of wavelengths, their peak emission moves to shorter wavelengths as their temperature rises. In the case of stars, both the peak emission and most of the total emission


Penzias and Wilson detected 2.7° K cosmic background at 7.35 cm.
30 megahertz
10 m
3.4 m
2.7 m
5.56 m
VHF Television Channels 2-13
1.38 m

usually fall in the visible band. For this reason, many astronomers thought up until a few decades ago that starlight made up the bulk of cosmic EM radiation.

But some stars — those much hotter than the Sun — are bright ultraviolet beacons. Other, much cooler stars glow in the infrared. And most important, we've found many cosmic sources of radiation, both thermal and nonthermal, that weren't even suspected in the early part of this century: bizarre binary star systems where swirling maelstroms of gas heated to millions of degrees emit X-rays, huge atomic and molecular clouds throughout the Galaxy that radiate exclusively in the radio and infrared regions of the spectrum, and the nuclei of "active" galaxies and quasars. These processes are far removed from the traditional, sedate, stellar universe of our predecessors.

In the realm of thermal sources, we encounter two types of spectrum — *continuous* and *line*. The former is produced by a hot plasma, like that inside stars, where free electrons swim through a sea of nuclei and radiate over a broad, continuous range of wavelengths. Line spectra, on the other hand, are associated with electron jumps within atoms, ions, and molecules. They consist of radiation at very precise, characteristic wavelengths. Visible light can also originate nonthermally, by a process known as *synchrotron* emission. But since nonthermal processes play a far greater role in making radiation of other wavelengths — especially radio waves and gamma rays — we'll look at them in more detail later.

Our perspective of the universe at visible wavelengths is important. Our optical window has revealed many of the basic building blocks of the universe, particularly the more lasting, stable elements like normal stars and galaxies. But visible light shows only part of the cosmic drama. To see it in its entirety we must move on, beyond the narrow window in which human eyes function.

The Radio Revolution

Early in this century, astronomers found the "radio window." It offered the chance for a completely new view of the universe. In 1930, a chance discovery by Karl Jansky, an engineer at Bell Labs, offered a strong hint of the radio window's true significance. Jansky found a source of radio waves in space. Shortly thereafter, astronomers identified the source as vast clouds of hydrogen gas in the interstellar regions of our Galaxy, and the science of radio astronomy was born.

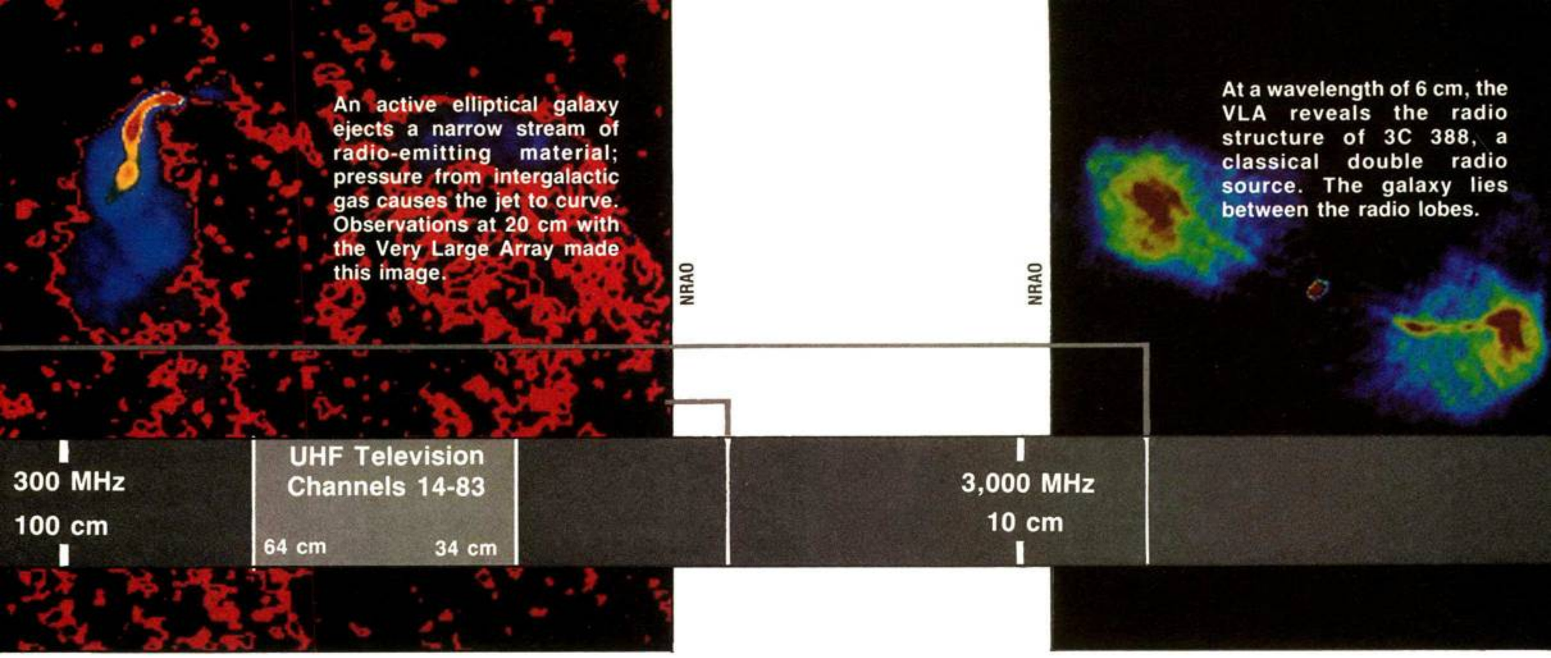
Today, we have access to all parts of the radio window, from wavelengths of shorter than a millimeter to those about 15 meters long. We use radio telescopes that, like their optical counterparts, consist basically of a parabolic reflector and a focal receiver. Radio telescopes, however, are immense — the largest is 60 meters or more in diameter. Generally, they are fully, or at least partially, steerable. But in the case of the world's biggest instrument, that of the Arecibo Ionospheric Observatory in Puerto Rico, no control of the reflecting dish is possible — it's constructed from a natural depression in the ground over 300 meters across!

Radio telescopes are big for a simple reason. Due to the longer wavelengths they deal with, their resolving power is, meter for meter, far less than that of optical instruments. As an example, the resolution for 6-centimeter radiation of the largest fully steerable radio telescope — a 100-meter behemoth at Efflesburg, West Germany — is 250 times less than the visible-light resolving power of most ground-based optical telescopes.

This could create a problem in trying to correlate radio observations with those at visible wavelengths, but astronomers have found a solution — the *interferometer.* This device is a cooperative array of widely spaced radio telescopes whose combined observations yield a much finer view of the radio sky. The resolution of an interferometer depends on the spacing of its component instruments. "Purpose-built" interferometers are relatively compact arrays of identical, generally mobile, radio telescopes. The Very Large Array, or VLA, on the plains near Socorro, New Mexico, is the largest instrument of this kind. It consists of 27 radio telescopes placed along the 20-kilometer-long arms of a Y-shaped array. The individual instruments are linked directly to a computerized "nerve center" and can achieve resolution on a par with that of ground-based optical telescopes.

A second class of interferometer boosts resolution to about 0.05 arc-second by using longer baselines (up to 100 kilometers). The 76-meter Mark IA instrument at Jodrell Bank, near Manchester, England, typifies this arrangement. It is connected by radio link to a series of smaller, remote-controlled radio telescopes at various outstations.

Finally, it's possible to make use of totally


An active elliptical galaxy ejects a narrow stream of radio-emitting material; pressure from intergalactic gas causes the jet to curve. Observations at 20 cm with the Very Large Array made this image.

NRAO

At a wavelength of 6 cm, the VLA reveals the radio structure of 3C 388, a classical double radio source. The galaxy lies between the radio lobes.

NRAO

independent radio telescopes, sited perhaps thousands of kilometers apart in different countries, in a technique called Very Long Baseline Interferometry. The telescopes make separate observations of the same object and store their results on magnetic tape together with precise time signals. The tapes are then dispatched to a central computing facility where the observations are combined to yield a high-resolution map of the object being studied. Astronomers have obtained resolution as high as 0.0001 arc-second with baselines that are nearly planet-wide.

The impact of the first big radio telescopes, in the early 1950s, could hardly have been more dramatic. Suddenly, we found a second window to the sky through which all sorts of startling new things could be seen. Through a series of discoveries made between 1951 and 1968, radio astronomy changed forever the way we preceive the universe. First, in 1951, came the discovery of the now famous *21-centimeter line*, emitted by clouds of atomic hydrogen within our own Galaxy.

When the atoms in a mass of cool hydrogen collide, they can tip their constituent electrons upside-down so that an electron's spin becomes aligned with that of the nuclear proton. The result is unstable, and the electron quickly flips back into anti-alignment with the proton. In doing so, it emits EM radiation in the radio-wave region with a characteristic wavelength of 21 centimeters. Although the process had been predicted seven years before, the actual detection of the 21-cm line was a major breakthrough. It paved the way for astronomers to map out the distribution of galactic hydrogen and, as a consequence, determine the structure of the Galaxy's disk, which contains almost all the hydrogen.

Following on the heels of the 21-cm find came another, far less expected discovery. In the mid- to late fifties, astronomers detected strong localized sources of radio waves at various positions in the sky. At first, it was thought that these might be some previously unsuspected form of "radio star." But upon close examination with the optical telescopes, a far more startling answer emerged. These radio beacons weren't stars at all. They weren't even objects within our Galaxy. They were complete galaxies in their own right, frequently odd-looking and very, very remote. Analysis of their spectra revealed some of them to be the most distant objects known.

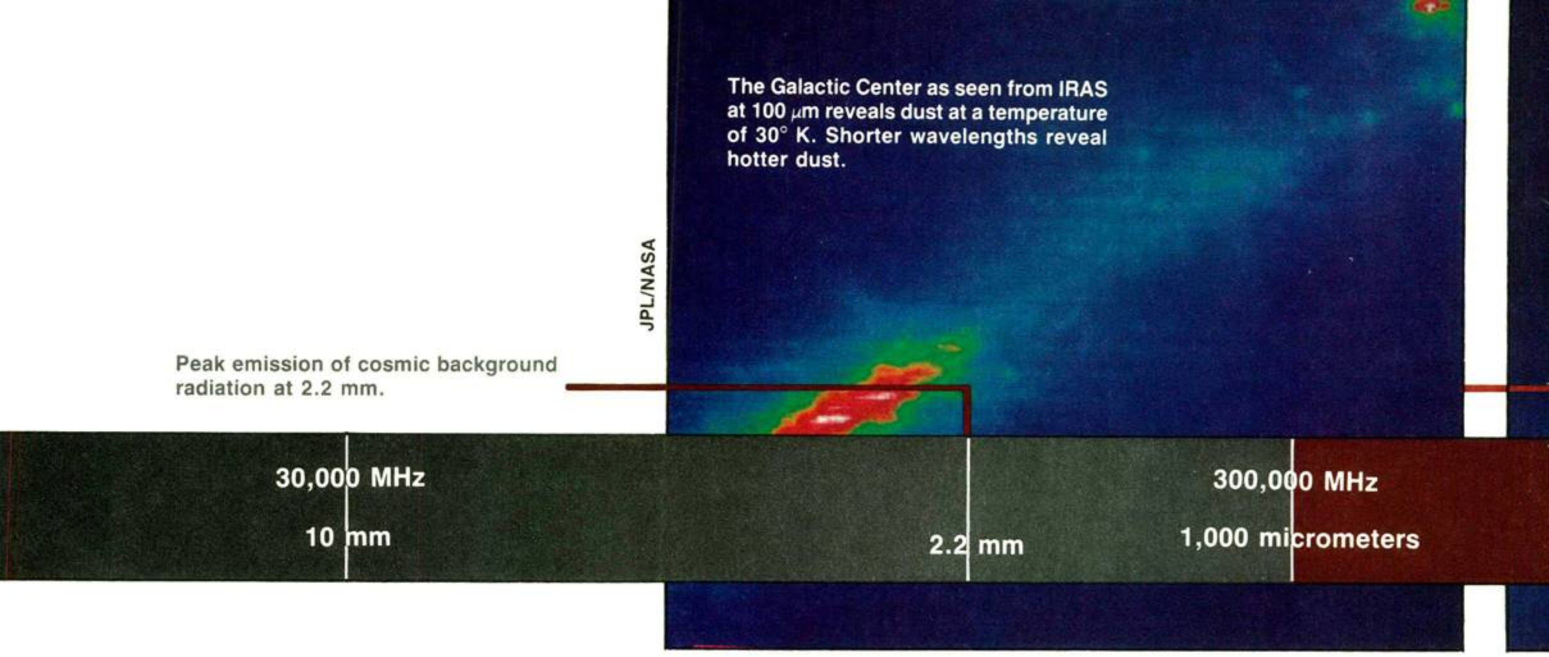
Were they galaxies in upheaval? Galaxies in collision? The latter possibility was favored for a time. Photographs of objects like Cygnus A seemed to show convincingly a titanic struggle between two great spirals. But the collision theory simply couldn't account for the prodigious energies involved. These new radio galaxies seemed capable of energy production on a scale that dwarfed that of normal galaxies, particularly in the radio region. Were they stellar systems that evolved along quite separate paths from galaxies like our own Milky Way? Or, since they were generally remote, and therefore from an earlier epoch of the universe, was it possible that they were actually direct ancestors of the less flamboyant galaxies of today?

Almost before the theorists could venture a reply, yet another, even more remarkable discovery rocked the astronomical world. In 1962, the Moon passed in front of the compact radio source 3C 273, enabling astronomer Cyril Hazard at the Parkes Observatory in Australia to determine its position with unusual accuracy. This allowed Rudolph Minkowski, using the Hale telescope, to identify its optical counterpart — an object that looked like a faint blue star with a curious spike extending out of its side.

But what star can be seen across a void of 2½ billion light-years? For this was the staggering fact that emerged a few months later when Palomar astronomer Maarten Schmidt revealed that the enigmatic spectral lines of 3C 273 were those of ionized hydrogen — shifted toward the red end of the spectrum by 14 percent! Here was no star at all, but the first of the mighty "quasi-stellar radio sources," later known as *quasars*.

3C 273 was a beacon still brighter than the radio galaxies — a more extreme example of violent events in the universe. Yet its starlike image gave no hint of galactic structure. All of its energy was pouring from a tiny region perhaps scarcely larger than our Solar System. What was the seat of its power? What was the "machine" that supplied it with more radiative energy than 100 Milky Way Galaxies?

More quasars were quickly discovered. Some are radio "active," like 3C 273, while others are radio "quiet." Some vary their output extensively in less than a day; others are more stable. We also know of other forms of active galaxy. BL Lacertae objects — "blazars" — are highly variable and have many quasar-like features. And the spiral Seyfert galaxies have intensely bright nuclei and



The Galactic Center as seen from IRAS at 100 μm reveals dust at a temperature of 30° K. Shorter wavelengths reveal hotter dust.

Peak emission of cosmic background radiation at 2.2 mm.

JPL/NASA

turbulent internal motions.

Gradually, a clearer picture of quasars and of the various types of active galaxy is emerging. Quasars are almost certainly the super-bright nuclei of young, hyperactive galaxies too distant to show easily their faint surrounding stellar suburbs. As evidence for this, many of the nearer quasars seem to lie in clusters of normal galaxies, and the majority of quasars, on close examination, reveal a fuzzy, galaxy-like structure around their tiny cores. BL Lacertae objects, radio galaxies, and Seyferts seem to represent intermediate links in the evolutionary chain connecting quasars with more peaceful forms of galaxy.

A key in all this is the central power source underlying the activity. Most of the galactic blockbusters we've mentioned pour out energy across a broad spectral range — in some cases, all the way from radio waves to gamma rays. What's more, their total radiant energy budget can be over 100 times that of the Milky Way. Whirling electrons close to the speed of light in strong magnetic fields, these energy tycoons of the universe emit non-thermal synchrotron radiation. Electrons must move in spiral paths when immersed in a magnetic field, and they emit radiation as they whip through space on their corkscrew courses. Radio observations often show this synchrotron emission coming from an immense double-lobed region centered on a much smaller object, which is often visible at optical wavelengths. Detailed maps of these "extended" sources, produced by interferometers, may also reveal jets of material that are accurately aligned with the large outer structures.

The compact energy machines of active galaxies and quasars may well be driven by supermassive black holes. (See "The Quest for Black Holes," ASTRONOMY, July 1983.) But there's still plenty of room for less exotic interpretations, perhaps involving chains of supernovae or other high-energy stellar events.

Pulsars make up a third major class of object found by radio astronomers. Faced with explaining rapid, precision-timed radio blips of extraterrestrial origin, scientists initially considered the possibility that they represented signals from other intelligences in the Galaxy. But this idea quickly evaporated, and a year or so after student Jocelyn Bell's serendipitous discovery of the first pulsar, CP-1919, in 1968, it was generally accepted that these objects were simply a very unusual kind of star. Pulsars, it appeared, were *neutron stars* — small-asteroid-sized balls of condensed nuclear matter whose existence was first suggested in the 1930s. But they were an unsuspected variation on the neutron star theme — a new cosmic species.

When a massive star faces its final energy crunch, it tears itself apart in a spectacular supernova explosion. If what's left of the star then has a mass between about 1½ and 3 times that of the Sun, it can only re-stabilize in a very hot, superdense nuclear state. The problem, on the face of it, is that such an object would be hard to detect. Only some "soft" (longer-wavelength) X-ray emission from its million-degree surface might reveal its presence.

Fortunately, pulsars add a new dimension to the observational aspects of neutron stars. Combining rapid rotation with a strong magnetic field, they emit radio waves, and occasionally visible light and X-rays, along two narrow, oppositely directed beams — like a lighthouse. They're a showy breed of neutron star that gives away its presence through the precision-timed signals. Perhaps the most famous of their line is PSR 0531+21 in the Crab Nebula, the object that clinched the connection between pulsars, neutron stars, and supernovae.

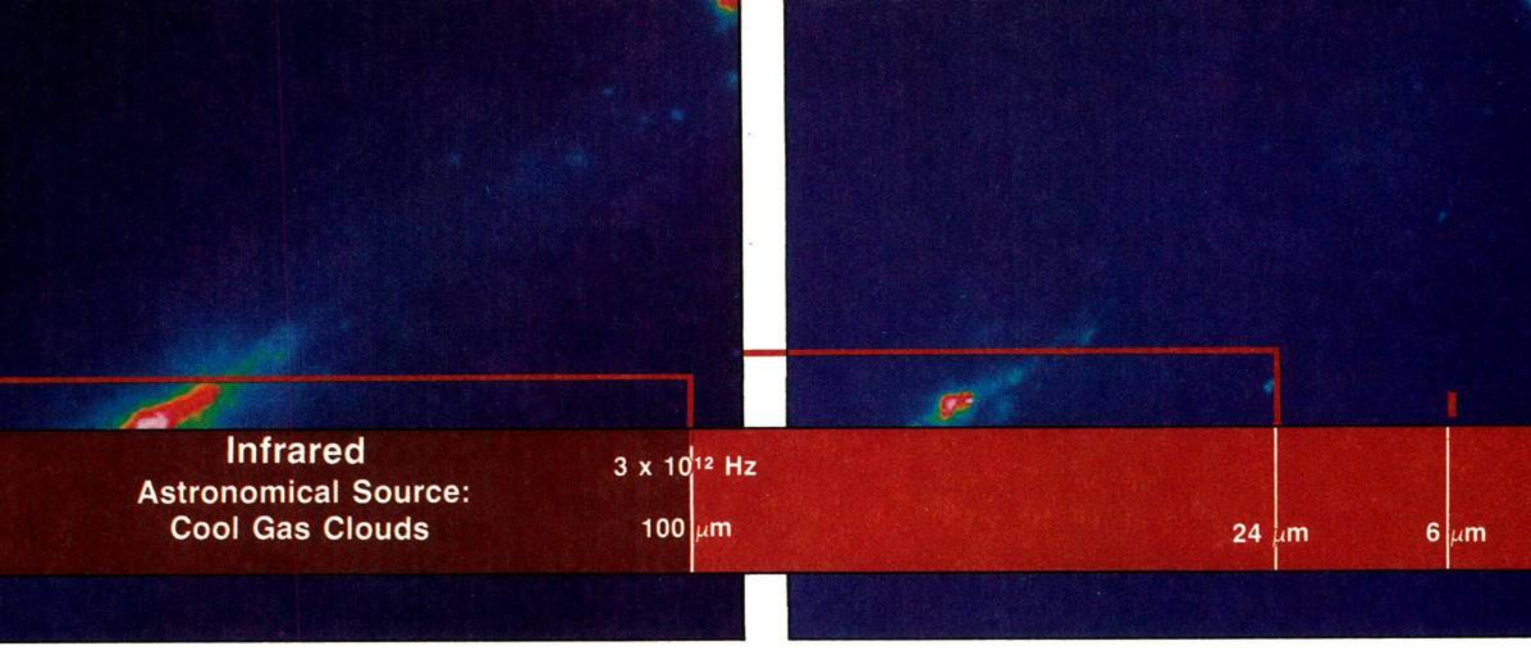
Maelstroms and Molecules

A strange irony led to the discovery of the cosmic microwave background. Two Bell Lab researchers, Arno Penzias and Robert Wilson, were trying to trace noise they believed might be associated with the same galactic source as that found by Jansky 35 years earlier. They built a monstrous horn-shaped receiver tuned to a wavelength of 7.35 cm especially for the task. Like Jansky, they found more than they bargained for.

A steady background "hiss" seemed to permeate all parts of the sky. As it turned out, the peak emission wasn't at 7 centimeters, but at 2 *millimeters* — in the microwave region of the spectrum. If thermal in origin, this radiation corresponded to a chilly 2.7 degrees above absolute zero! What could it possibly be?

Cosmologists were quick to expose the mystery. The newly found background was, almost certainly, remnant radiation from the Big Bang itself, the dying ember of the unimaginably hot fireball in which our universe was born.

Penzias and Wilson, who shared a Nobel prize for this discovery, had taken the first bold step into an



uncharted realm of the EM spectrum. Between the centimeter-band at the limit of traditional radio astronomy and the micrometer-band of the infrared was a "no-man's land" waiting to be explored.

No one really knew what to expect at these short radio wavelengths. At 21 centimeters, atomic hydrogen had been detected. And, in 1963, at 18 centimeters, the hydroxyl group (OH) had been found. But there seemed little prospect for the discovery of other chemicals between the stars.

Fortunately, physicist Charles Townes disagreed. In 1953, he had used ammonia to build the first *maser*, the microwave version of a laser. In 1968 Townes used a special-purpose 6-meter dish at the University of California to detect in our Galaxy the 13-millimeter radiation of ammonia molecules emitted by the maser process. It was a landmark event — the simultaneous birth of millimeter astronomy and "astrochemistry."

Since then, dozens of other molecules have been found in space. They inhabit thick, dark molecular clouds, and the reason for their existence is becoming clear. They start out as ions created by cosmic rays, then gradually build into chains of increasing complexity, shielded from damaging stellar radiation by the surrounding dense cloud.

The millimeter-band has been a profitable hunting ground for astrochemists. But the rewards were hard won. The shorter the wavelength you wish to explore, the more accurate must be the reflecting surface of the radio telescope. High-precision dishes are the order of the day.

Soon, radio astronomers will penetrate even further — into the submillimeter-band. A new British 15-meter instrument is already being assembled on Mauna Kea in Hawaii; it is specifically designed to operate in the range of 1 mm to 0.3 mm. The site is well-chosen. At short wavelengths, the radio window begins to break up due to atmospheric absorption by water vapor. An unusually dry site is essential for effective observation. Beyond 0.3 mm, the radio window closes entirely — our next chance for ground-level astronomy is in the infrared.

Astronomy in a Heat Wave

We don't really talk about an "infrared window" as we do a radio or optical window. The infrared transmission properties of the atmosphere vary tremendously from wavelength to wavelength, from site to site, even from day to day. The main problem, again, is absorption by water vapor. All ground-based infrared astronomy must be done from sites that are especially high and dry.

One of the driest sites in the world is the 4,500-meter-high volcanic caldera of Hawaii's Mauna Kea. It's already home for the two largest infrared telescopes — the 3.8-meter UK Infrared Telescope and 3.0-meter NASA Infrared Telescope Facility — as well as being the site chosen for the new 15-meter submillimeter dish. Other major instruments for use in the infrared include the University of Wyoming's 2.4-meter Infrared Telescope, and modified optical telescopes like the MMT and the venerable 5-meter Hale telescope on Palomar Mountain.

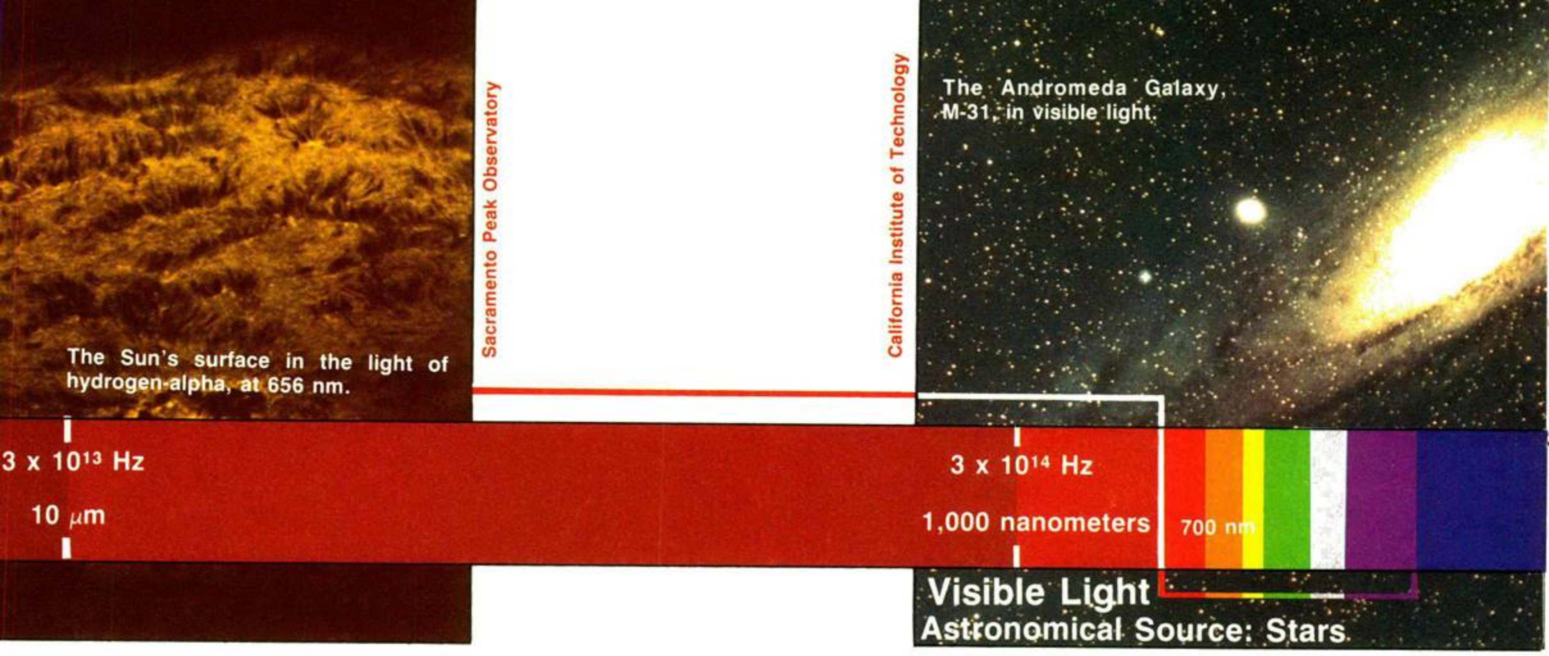
Purpose-built infrared telescopes are generally cheaper to make than their optical counterparts. Because of the longer wavelengths with which they deal, their reflecting surfaces need not be as accurately configured or distortion-free. As a result, both the primary mirror and the remaining structure of the instrument can be of lighter, more economical construction.

But working in the infrared presents a whole new set of problems that aren't encountered at visible wavelengths. The most significant problem is that the telescope itself becomes a potentially overwhelming source of the very type of radiation that it's trying to detect!

Objects at room temperature or thereabouts emit most strongly in the infrared. Hence, trying to observe in the infrared with an unmodified, conventional telescope would be as futile as attempting optical astronomy with an instrument bathed in floodlights. The way around the problem is to cool the infrared detector to temperatures near absolute zero. This cryogenic cooling is usually achieved by circulating liquid helium around the detection equipment.

The complete infrared range extends from less than 1 micrometer, where it merges with the red end of the visible spectrum, to the millimeter-band, where it blends into the radio wave region. However, of this, only fragments manage to reach ground-level. Small atmospheric port-holes exist in the 2 to 25 micrometer and 30 to 40 micrometer bands, but even at high altitude these vary in clarity.

The solution? Supplement terrestrial and balloon-borne infrared observations with those made from space platforms. This was done most recently by the launch, in


The Sun's surface in the light of hydrogen-alpha, at 656 nm.

Sacramento Peak Observatory

California Institute of Technology

The Andromeda Galaxy, M-31, in visible light.

January 1983, of the *Infrared Astronomy Satellite* (IRAS). (See "IRAS: Mission Invisible," ASTRONOMY, April 1983, "IRAS and the Infrared Universe," March 1984, and "Astronomical Ballooning," this issue.)

IRAS was an international venture, built in the Netherlands, incorporating a 57-cm telescope supplied by the U.S., launched by NASA, and controlled from the Rutherford Appleton Laboratory in England. Most importantly, it carried with it detectors designed to work in four spectral bands — from 8 to 120 micrometers — largely inaccessible from the ground.

Previous infrared studies — performed at ground-level, by balloon-borne instruments, and by other means such as NASA's Kuiper Airborne Observatory — had indicated what type of objects might be prominent in the infrared universe. Warm interstellar clouds with temperatures between a few tens and a few hundred degrees Kelvin head the list. These clouds are often the sites of star formation and their own infrared emission is generally augmented with the radiation of stars in the final stages of pre-stellar collapse.

We've known for some time that some large dusty clouds form supermassive, superluminous stars. But the infrared emission of smaller, more numerous clouds — regions that probably form low-mass stars like the Sun — is too low to detect from the ground. Now, IRAS has provided the first evidence for the birth of stars with masses as small as the Sun's. Low-mass protostars apparently exist in at least two small dark clouds: Barnard 5 and Lynds 1642.

The general processes leading to star formation are still under discussion. Obviously, this is a key question in our understanding of the evolution of stars, galaxies, and ultimately, the universe. IRAS provided additional data by studying the infrared emission of potential star-forming regions in other galaxies. Its investigations revealed the infrared glow of optically dark dust lanes, regions that seemed primed to form the basis for new generations of stars.

IRAS also turned its cryogenic eye toward interacting galaxies. The satellite revealed unexpectedly widespread star formation in regions where galaxies interacted. Astronomers are debating the solution to this mystery, but the eventual answer will no doubt shed light on the relative importance of various processes known to be capable of triggering stellar collapse.

Dusty regions aren't exclusively associated with stellar embryos. They frequently crop up as circumstellar shells around stars that have already ignited their central fires. Dusty shells are common around stars with strong stellar winds — a category that includes both bright, young stars, like O, B, and A types, and older objects such as red giants, the peculiar Wolf-Rayets, and the central stars of planetary nebulae. In these cases, the infrared emission comes not from the star itself, but from the surrounding dust grains warmed above the normal chill of interstellar space by the star's radiation. One of IRAS's headline-making discoveries was of a ring of warm dust particles in orbit about Vega; since then, project scientists have found 50 similar sources. The size and temperature of Vega's cloud suggest that it could be a pre-planetary nebula — a new solar system in the making.

At least one other class of object — galactic nuclei — is known to be a strong source of cosmic infrared. As a matter of fact, the core of our own Galaxy harbors an unusual infrared source. It is dwarfed, though, by the infrared emission of systems like the Seyfert galaxies, BL Lacertae objects, and quasars. These giants of the infrared universe — representing perhaps 1% of all known galaxies — are generally at least 100,000 times more powerful in the infrared than the nucleus of the Milky Way. In common with all galactic nuclei, though, their prime emission process appears not to be thermal — as in the case of dust clouds — but rather due to the synchrotron mechanism.

The future for infrared astronomy seems to be very bright. Already there are plans for a European Space Agency satellite with at least twice the 11-month lifetime of IRAS. The Space Telescope will carry detectors and spectrometers for observation in the infrared, as well as the visible and ultraviolet regions. And, most intriguing of all, there's NASA's *Cosmic Background Explorer*, planned for 1987. This instrument is designed to operate at wavelengths from the infrared to radio waves and to look specifically for radiation that has reached us from the origins of the universe.

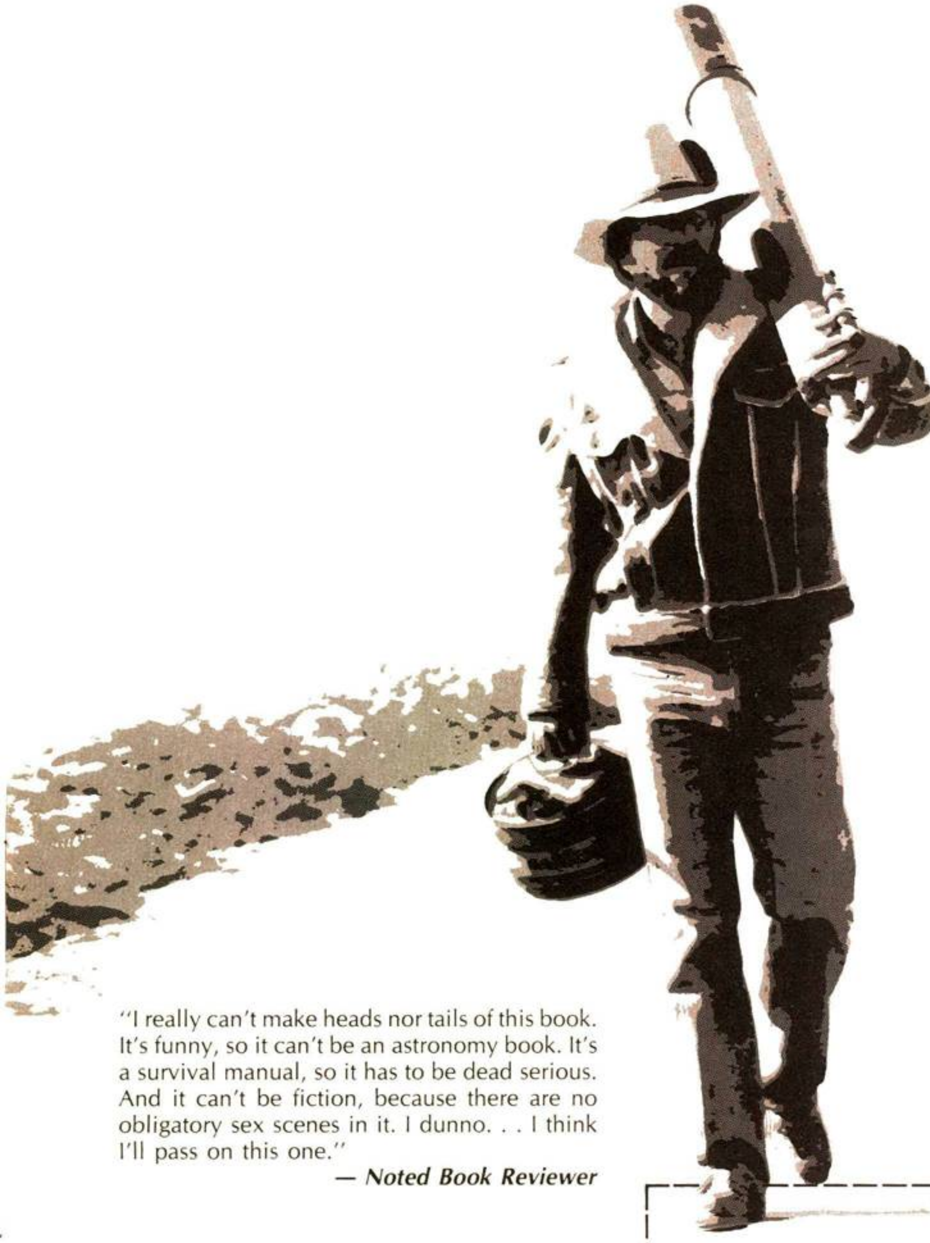
David Darling, who received his Ph.D. in astronomy from the University of Manchester, England, is a computer consultant and freelance science writer. His last article in ASTRONOMY *was "The Quest for Black Holes," in the July 1983 issue.*

AstroMedia Presents:

The Light-Hearted Astronomer

by Ken Fulton

A Survival Manual for Amateur Astronomers



"I made a big mistake when I purchased my first telescope. How I wish Fulton would have written this book sooner!"

— *Galileo*

"I was lost and near death in astronomy's jungle. **The Light-Hearted Astronomer** saved me. As a token of my gratitude, I am sending Ken Fulton twelve billion dollars, four of my seventy-three wives, and sixty-three camels. If he doesn't smoke, he may return the cigarettes — but the wives stay."

— *A. Sheik*

"Fulton has done astronomy an invaluable service. I think a lunar crater should be named after him."

— *Plato*

"Look . . . my husband eats, drinks, and sleeps astronomy while I work my fingers to the bone keeping our household afloat. He loves astronomy so much that he'll probably spend what money he makes off this book to buy another eyepiece or something, even though I badly need a new mop. And you want me to write something praiseworthy about this book? You've got to be kidding!"

— *Doris Fulton, wife of the author*

"I really can't make heads nor tails of this book. It's funny, so it can't be an astronomy book. It's a survival manual, so it has to be dead serious. And it can't be fiction, because there are no obligatory sex scenes in it. I dunno. . . I think I'll pass on this one."

— *Noted Book Reviewer*

The Light-Hearted Astronomer

$6.95

128 pages, paperback,
$5\frac{1}{2}'' \times 8\frac{1}{2}''$

Foreign orders add $1.50

The Light-Hearted Astronomer
Ken Fulton

☐ **Yep,**
I gotta have me a copy!
Here's my $6.95.

☐ **I want some for my friends.**
Send me __________ copies, and
here's my check for $________.

Name ________________________

Address ________________________

City __________ State _____ Zip _____

Send this coupon or a copy to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202, or use the handy order form bound into this magazine.

ASTRONOMY
Forum

Hit and Run...

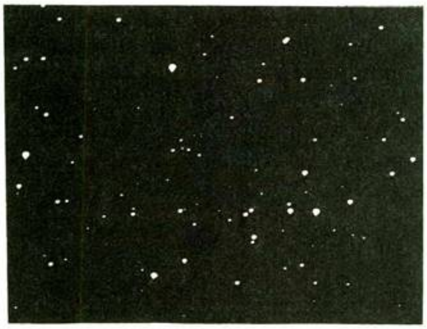
The high clouds responsible for the less-than-perfect viewing conditions began dispersing about 1:30 a.m. That's just what I needed: a little opening here and there, letting bits and pieces of heaven through for my hungry eyes to late-night-snack upon. Cassiopeia showed herself first. I adjusted my 6-inch reflector toward her and wandered through her glorious playground. Multiple stars in shades of green, topaz, and gold, just to mention a few. Might as well try for Iota, the triple system — I've seen it before on super-steady nights. O.K., there it is, yup that's it. Good . . . that's rare . . . for me that is. Now for some clusters. It's really clearing fast . . . M-52, nice . . . M-103 . . . this is great. Hmmm . . . what's that one? Better check my sky chart.

Turning on my red-lensed flashlight, I traced the giant M of Cassiopeia until I had a bead on this next cluster. Back to the scope. Back to the chart. Back to the scope. Back to the chart. Once more to each of them. It's NGC-457 — all right, something new!

Much of the sky had completely cleared by now. I should check some other constellations before I sleep for the night. Let's see . . . where to start? It's suddenly all so crystal clear . . . long as the scope is over this way, think I'll check in on M-31, the Andromeda Galaxy. It's usually easy to find . . . there it is . . . this thing is more than a mere smudge tonight — I'm seeing a full five degrees or more.

An untimely burst of yapping rudely grabbed for my attention — and got it. Hell, I nearly fell over with surprise. It's similar to vertigo . . . you're gazing into space, consciousness fixed on splendid events taking place eons in the past, completely unaware of function and whammo! . . . one of your other sensors is overloaded and the feedback of your reaction leaves you feeling like an unbalanced stranger on terra firma.

So what's with these coyotes? Sounds like every one of 'em within a 10-mile radius is joining in the chorus. Well, like they say, if ya can't beat 'em, join 'em. The yelp I belted out took *them* by surprise. Momentarily they stopped. But that lasted only a few beats. I suppose one or two on the fringe didn't hear me so it all began again, only this time louder. That's not gonna stop me, I thought aloud. It's an easy swing from M-31 over to M-33; right over there . . . in Triangulum.



Not a cloud in the sky . . . that was quick, only 'bout half an hour ago you could've called it overcast.

Let's see, up a couple, over a little . . . where is it? Let me try again . . . there's Triangulum, there's Mirach, right between . . . all *right*! There it is, I'm getting better at this! It's a beauty, focus it in a little better . . . there, there, whew . . . just don't get much better, never seen it so crisp, so detailed. So . . . hey, where'd it go? I'm looking right at it and, poof, it vanishes. Must be a wisp of a high cloud . . . maybe I bumped the scope. Yanking my head from the scope, I strained my confused eyes in search of the cloud, or whatever might be getting between M-33 and me. Nothing . . . nothing . . . clutching my binocs, I semi-frantically scanned M-33's neighborhood. Nothing . . . not a trace, not a cloud, nothing but blackness, empty blackness, darker than just mere emptiness.

Mechanically, and somewhat dumbfoundedly, I switched on the red light again, and for some reason glanced at my watch . . . a minute or so past 2 a.m., October 31st. So what? No — *wait*, it's the end of daylight savings time! My chin held the light while my hands got busy changing the watch. If I don't do it now, I'll be an hour off tomorrow. How un-loyal of a machine. Anyone could sneak up and easily alter it, and the two-faced little son of a gun would claim to be true if you called upon it for a reference. Spring forward, fall back . . . thank goodness for all those little jingles that help us through our daily challenges. How many days in this month? That's easy — 30 days hath September, April, June, and November. . . .

The coyotes had faded. I didn't even notice it happening, but they did. That's neither here nor there, but neither is M-33.

I tried for a good 10 minutes more to no avail. I lost it. Then I decided to fail gracefully, and withdraw with honor. I was getting tired anyway; I'll find it tomorrow night. A long, loud, and effective yawn put the icing on the cake, and sent me packing. Luckily, all my equipment was light and easily handled.

Sleep came fast, and deep and flowing dreams kept the edge of questions from disturbing my peace. My peace was extreme — it held me in bed till 12:30 the next afternoon. It was raining anyway, so I didn't exactly hop up, bright-eyed and bushy-tailed. The rest of the day was mildly uneventful. The rain continued *throughout the night, and in fact,* throughout the rest of the month of November, putting a damper on any sky shows that might be hiding behind

Two Great Magazines from AstroMedia

AstroMedia Corp. has been publishing ASTRONOMY for over 10 years, but did you know about TELESCOPE MAKING and DEEP SKY Magazines? Both are authoritative quarterlies, written with the amateur astronomer in mind.

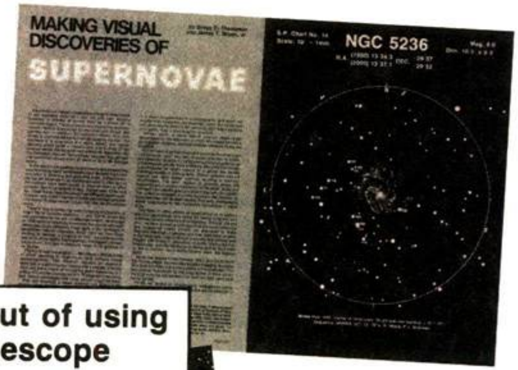
Whether your interest is building your own telescope or observing and photographing deep-sky objects, get the facts from those who know.

Subscribe now!

TELESCOPE MAKING

- Learn about mirrors, eyepieces, mountings and observatories
- Discover the fine points of telescope optics
- Read about Dobsonians, Poncet platforms, automatic guiders and computer ray tracing
- Follow new developments from Stellafane, Riverside, Texas Star Party and Astrofest
- Save money when you build your own telescope
- Each issue 48+ pages

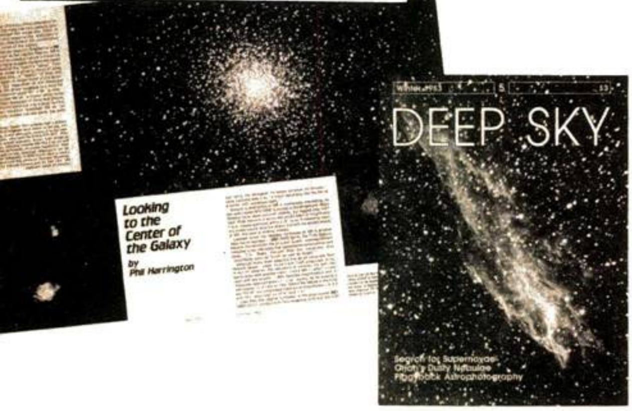
TELESCOPE MAKING
Subscription Price:
$12.00 one year (4 issues)
($14 outside USA)
$21.00 two years (8 issues)
($25 outside USA)

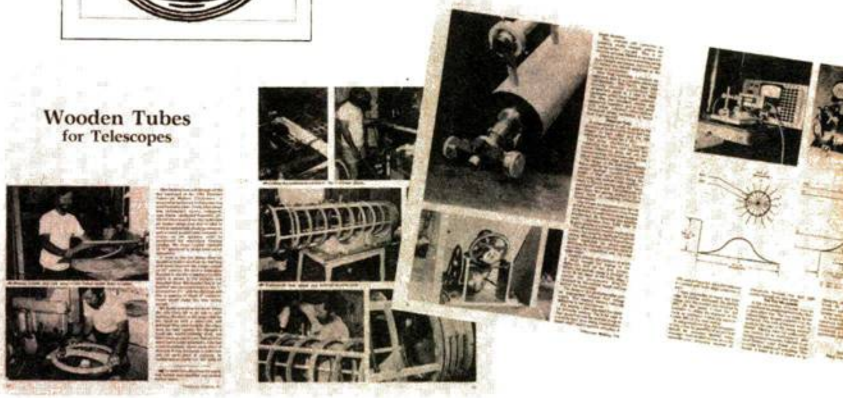

MAKING VISUAL DISCOVERIES OF SUPERNOVAE
NGC 5236

TELESCOPE MAKING
21

More about telescopes than any other magazine in the world

Get more out of using your telescope


Looking to the Center of the Galaxy
by Phil Harrington
DEEP SKY
Search for Supernovae
Orion's Dusty Nebulae
Piggyback Astrophotography


Wooden Tubes for Telescopes

DEEP SKY

- Read about supernova searching, Schmidt photography, observing quasars and low surface brightness nebulae
- Discover hypersensitizing, filters, image tubes and large-telescope targets
- Find the sky's secret showpieces
- Learn how to photograph deep-sky wonders
- Quality photo reproduction on heavy high-gloss stock
- Each issue 40+ pages

DEEP SKY
Subscription Price:
$10.00 one year (4 issues)
($14 outside USA)
$18.50 two years (8 issues)
($26.50 outside USA)

— Get the facts from those who know —

Enter my subscription to:

☐ **TELESCOPE MAKING**	☐ **DEEP SKY**
☐ new ☐ renew	☐ new ☐ renew
☐ 1 year **$12** ($14 foreign)	☐ 1 year **$10** ($14 foreign)
☐ 2 years **$21** ($25 foreign)	☐ 2 years **$18.50** ($26.50 foreign)

Subscriptions begin with the next issue.

Name

Address

City State Zip

☐ Bill me. ☐ Payment enclosed.

Send to TELESCOPE MAKING/DEEP SKY Subscription Dept., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202.

63484

those clouds. The rain and overcast also put a damper on my memory of the vanishing galaxy, until finally a clear night strolled along and snapped me back to face the mystery.

Nonchalantly, I gazed into other constellations, enjoyed other far-away nebulae and clusters. Toured more sporty galaxies, ones not playing hide and seek with my lowly amateur astronomical status. Whoever invented the process of elimination had my number. There I was again, drinking in the profound beauty of M-31. Bigger than our galaxy, yet similar in structure. Over two million light-years away, yet imprinting its glow in my delicate sensory devices, now . . . *now* over to M-33. There's Triangulum. There's Mirach, there's . . . try again, up a degree or two, over a tad . . . must be a mental block. Let's try the binocs, they make locating much easier . . . should be right about there . . . maybe over a little . . . try the chart . . . O.K., should be easier this time. Patience, patience . . .

The next month was unusually cloudy, again limiting any chances to continue the mission — by now, it was a passion, a passion I was a bit shy of sharing with anyone. Maybe "embarrassed" would explain it better, although I did casually bring up the subject with a few friends. One had astronomy courses at a prestigious university, but I think her infatuation with astrology prevented any real absorption of the true scheme of the heavens. Once she was explaining how I would be during the coming weekend, since the Moon had just entered the sign of Pisces. Allowing her to finish, my response was one of sincere want of understanding. "But right there, in plain view, the Moon is undeniably in the constellation Aquarius. Is it possible there's a mistake in your book?"

"No," she snapped, "the sky is wrong."

Well, obviously we had a personality clash or something. The other friend claimed to be no expert, thank the gods. He'd been studying on his own for several months and had a great set of binocs. He was all too willing to help me relocate M-33. One crisp night in the middle of February, he turned, pointed to Orion, and said, "Hey look! The Big Dipper."

Without further ado, I retreated to the science journals for comfort and understanding . . . and found it . . . temporarily, anyway. What I found was a well-known fact I'd never heard before. It's this: M-33 can play hard to get. Sometimes, it's simply hard to locate. Well at least I had some reason not to doubt my sanity, but not much. The word "sometimes" can be very haunting, sometimes. I had to admit — it was more than "sometimes," it was months and months it had been missing. That's more like "ever since" than sometimes. Yeah, ever since we lost daylight savings time. That's strange, isn't it? We gain an hour and lose a galaxy. Doesn't seem fair, but who holds the Blue Book on the resale price of time?

But come to think of it, not only is M-33 missing, that's nothing compared to the other side of the coin . . . the damn thing vanished, I saw it happen. Now ya see it, now ya don't. So I made a few calls to universities and observatories. They admitted that sometimes M-33 is difficult to locate, but none of them wanted to discuss the vanishing act to any degree. One professor at least said he'd have a "look-see" and let me know what he found. I take it he found nothing since that's what I heard from him. There I was . . . alone in my quest, the sole witness to a cosmic whodunnit. But no charges were filed, not even a complaint was issued. There was no court on Earth, or the heavens, that would subpoena me to testify for or against the allegations. Was a crime even committed? Who was the victim? I was. Let's call it a galactic "hit and run."

Rick Dilsizian

In like a lion. March arrived and decision-making time was knockin' on my noggin. I wasn't ready to answer, but I did anyway. I had no choice. I decided to take the scientific approach and do nothing. After all, what could I do? I seriously doubted that M-33 was doing anything about me. If it was, I hoped it had more success than I'd been having, especially if I turned up missing.

Why linger on your problems? Another will be along soon enough. Cancer has plenty to offer in the way of clusters, and Leo is right next door with galaxies M-65 and M-66 and M-95 and M-96 just waiting for some fool like me to look 'em up. So I did. So I stayed over that way through March and got Saturn, and later on even Jupiter as a bonus. The Full Moon at the end of the month kind of screwed things up, but I did catch it rising, *that's* always a treat. And how's about Venus after sunset? It's been hanging in there for over a month, getting more and more gibbous. Mars has been visiting with it, but it's fallen by the way as we shifted into April.

April was always one of those quick months. Poised at the beginning of spring, and dangling the promise of summer in its flowering clutches. I've been up late often lately, and good ol' Sagittarius has been keeping me busy. Diving into the galactic center has always been high on my sky list.

Well, the fourth weekend in April rolled around, and some friends had a surprise party scheduled for me on Saturday night. My birthday was actually the following Sunday, but what Saturday night party ever ends at midnight? I picked up on the surprise bit early, but played along with it for their sake.

During the course of the party, the subject turned to astronomy and, of course, that led to the missing galaxy, M-33. I wasn't the one who brought it up, but it did become the standard joke of the night. Instead of thinning out, the party grew as it got later . . . it turned out to be quite a bash. The missing galaxy jokes began to bore me. One clown in particular had located it on the sky chart using the information I'd spoken of as a guide. "Looks easy enough to find . . . you sure you ain't losing your sight?" It finally went too far, and I gathered my scope, binocs, flashlight, and chart. The proof would lie in the pudding.

Out we went, me and my entourage of doubters. Giving them the abridged course in amateur astronomy, and letting our eyes adjust to the night for a bit, I began pointing out little wonders, here and there. Passing around the binocs, they each "ooohed" and "aaahed" with each new sight.

The moment of truth had arrived. Andromeda lay low on the northern horizon. I fixed the scope on the Great Andromeda Galaxy, M-31. Again they each took their turn, and this one brought a much more tangible note of respect for the heavens. Let's see, over a little this way . . . try again . . . there's Mirach, there's Triangulum, right between them . . . that's where it should be. My audience trusted and understood more, since the view of M-31 opened their eyes. The red light on the chart showed where M-33 should be, and everyone was now helpful. They took turns slowly transversing the scope, searching with the binocs, holding the red light for each other. They all agreed it was missing. Well, they were in on the mystery now.

Meanwhile, the sky moved, and I was involved in resetting the scope back to the scene of the crime, for my friends wanted to keep trying. Why not? They were new recruits on the

The pick of the pack!

The Celestron C8 is the optical standard against which all 8" Schmidt-Cassegrain telescopes are judged. Light weight, easy to operate, and optically superb, the C8 can be your window on the Universe!

Just look at what you get for only $999 with Celestron . . .

- *Hand-polished,* laser-collimated, and individually certified optics.
- Dual motor electric clock drive — for sure, steady tracking.
- A light-weight and ultra-stable locked-triangle tripod, equatorial wedge, setting circles, dust cap, slow-motion controls on both axes, 25mm *orthoscopic* eyepiece (80x) and quality 2x Barlow (160x), wide field 6 x 30mm finderscope, a lockable foam-lined carrying case.
- A **25% savings** and a **25-year warranty**!

Want some low-cost higher-performance C8 options? Add $100 optical coatings — for a 10% increase in light transmission and better contrast for photography and dark sky visual work — for only $76. An adjustable height tripod is only $37.50 more.

~~$1331 00 list~~
$999, plus freight
C8, wedge, tripod

CELESTRON®
PRECISION OPTICS

~~$595 00 list~~
$479, freight paid
Criterion 4000, complete

Ideal as a spotting scope, telephoto lens, or an ultra-portable complete astronomical observatory, the Bausch & Lomb Criterion 4000 is a winner any way you look at it! It's a 4" 1200mm Schmidt-Cassegrain complete with contrast-enhancing special optical coatings, 40x and 67x 1¼" eyepieces, table-top tripod, finder, electric clock drive, slow motion controls, carrying case, and **a lifetime warranty**! You save almost 20%!

Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the more than 70 telescopes and 500 accessories we carry — from Celestron, Bushnell, Meade, Questar, Edmund, Coulter, Unitron, TeleVue, Lumicon, University Optics, and more — or send $1 for our complete catalog that takes the guesswork out of picking the right telescope!

BAUSCH & LOMB
Prices good through 8/30/84.

ad·libs astronomics

2401 Tee Circle, Suite 106
Norman, OK 73069 (405) 364-0858
Now in our sixth year of saving you money! Mastercard, Visa.
Freight additional on credit card orders. North American sales only.

Bring the Entire Night Sky into Your Home

Nearly 6,000 stars — every star visible to the naked eye — are plotted on **The Star Map**'s 30 x 60 inch black diazo surface. Each star is scaled in size to indicate its apparent brightness — so they appear just as they do in the night sky. And all major stars and constellations are labeled for easy reference.

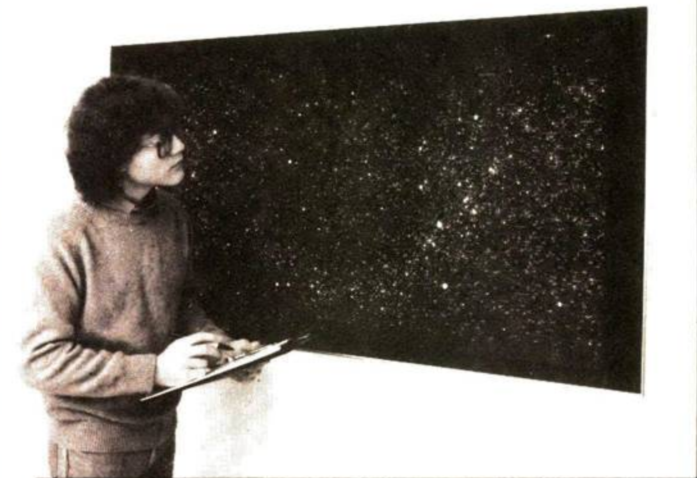
The Star Map — A functional and attractive tool for the beginning or the veteran stargazer.

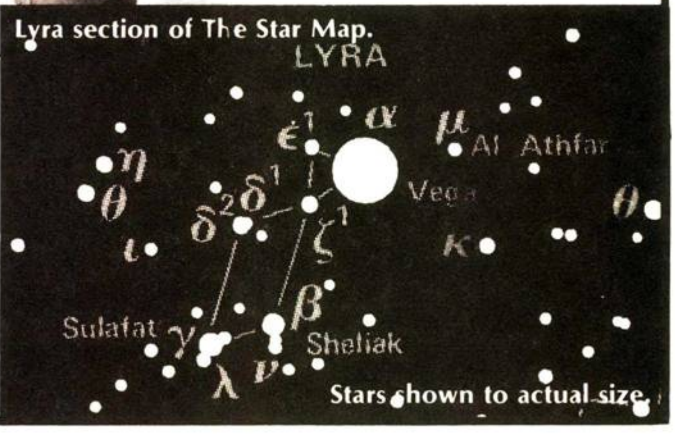
$12.95

Shipped in a sturdy tube

To order, use the AstroMedia order form bound into this issue or send to AstroMedia Corp., Order Dept., P.O. 92788, Milwaukee, WI 53202.

Star Map copyright © David W. Teske, 1979. All rights reserved.





Lyra section of The Star Map.

Stars shown to actual size.

job, and the tracks seemed fresh to them. O.K. there's Mirach, over a little . . . that's the spot, it should be right there . . . but of course it wasn't. Wait a second! There *is* something there! Very faint . . . but getting more luminous right before my eyes! It's M-33 — it's back!

As I gazed in complete astonishment, I heard this brief conversation behind me: "What time ya got?" "Oh, just about a minute past two a.m. Time to turn the clocks up an hour; it's daylight savings time." "How's that go? Spring ahead, fall back . . .?"

J. Jasper McElwee
Calabasas, CA

A Talk with Walter Cunningham

A poet, painter, or philosopher may soon venture into space.

That's the prediction of former astronaut Walter Cunningham, pilot of the first manned mission of the Apollo program.

Cunningham, who orbited the Earth 163 times and spent 11 days in space on Apollo 7 in October 1968, told British aviation enthusiasts at London's Earls Court earlier this year that NASA officials are seriously considering sending a representative "man in the street" into space aboard a future Shuttle flight.

"They are going to select somebody to go along — and I am talking about an artist, or a poet, or someone like that, who will go up and properly dignify the space experience so that a bunch of dumb astronauts like me don't return to Earth and say, 'It was beautiful and marvelous,' or 'Jiminy Cricket and gee whiz!'"

But Cunningham is skeptical of this plan's value: "I maintain that we astronauts could probably do just as good a job of it as they can — and that they would probably not get as much out of it. You don't have to go out into space to wax poetical about that particular experience," Cunningham continued.

He added that, considering the cost of sending one individual into space, sending him just so that he could say "ooh" or "aah" on the return would not be worthwhile.

Cunningham said that while he tended to agree with Winston Churchill's remark that Americans and the English are two great peoples separated by a common language, he thought that British science-fiction author Arthur C. Clarke had best characterized what Americans are really doing in space: trying to move out the horizons of man. Quoting Clarke, Cunningham said, "We have embarked on a voyage on an ocean whose farthest shores we can never reach."

Cunningham also said the Space Shuttle transportation system was being developed to benefit people of all nations. "We have probably the world's best delivery system for putting satellites into orbit, and 90% of American payloads over the next 20 years will be carried in this space truck," he continued. "The vehicle looks exotic, the mission is exotic, but believe me this craft is nothing more than a practical-minded truck. The cargo bay is 60 feet long, 15 feet wide, and will carry up to 65,000 pounds."

Replying to a questioner who asked what it would mean to U.S.-British relations if the rumored flight of a British astronaut on a future American Shuttle flight actually happened, Cunningham replied, "Hopefully, nothing. We have been friends for a long, long time, and while we have our differences, we seem to resolve them very well. But I'll say this — it will make a big difference in that man's life. All of a sudden he'll be a curiosity. I won't have to come over here to let the British people see what an astronaut looks like — you'll have your home-grown variety."

Discussing the parity of the American and Russian space programs, Cunningham said that there had been one significant operational difference during the first 20 years — that of having a man in the "loop."

He explained: "America's Shuttle *Challenger* has been designed with the ability to come back and land automatically — they say. During its flights the pilots have checked out different parts of it. One guy, for example, turned on the automatic landing system and used it from 1,500 feet to 500 feet, another person used it from 50,000 to about 10,000 feet, and then took over manually.

"Some day, they are going to find an astronaut who will just sit there, hold his hands in the air, and let the thing land itself. That hasn't been the case so far, and I like to think it would work. But what I'd like to tell you is that the automatic system has been qualified — checked out — by the fact that a man has been doing these things."

Cunningham said that, rightly or wrongly, American astronauts had been involved in the designs of space vehicles from the very start.

"We always insisted that our craft operated with us flying them. I know that in Apollo if we had died in orbit that spacecraft would still be going around the Earth. So we were in the loop," he explained.

"But the Russian program," Cunningham continued, "was designed exactly the opposite. Because of their passion for secrecy they wanted unmanned recovery capability. So in their case, if the subject expired they would always be able to get the spacecraft back.

"And I suspect that today this is still true, that all their spacecraft could operate with or without that man being in there. And that accounts, for example, for why they were able to fly Valentina Tereshkova 20 years ago, because they could have flown anybody."

Discussing the Shuttle's performance, Cunningham said its newly developed engines have a much higher thrust than previously developed models. "They represent the latest in liquid oxygen-liquid hydrogen technology. Probably one of the areas where we maintain a very significant lead over the Russians is in that kind of a propulsion system," he said. "The engines are designed to be used and re-used, started and restarted, over and over for a minimum lifetime of 700 minutes. The longest I know of with earlier engines, the restart capability might have had a projected lifetime of 12 or 15 minutes."

Cunningham concluded by mentioning America's lack of secrecy about its space program.

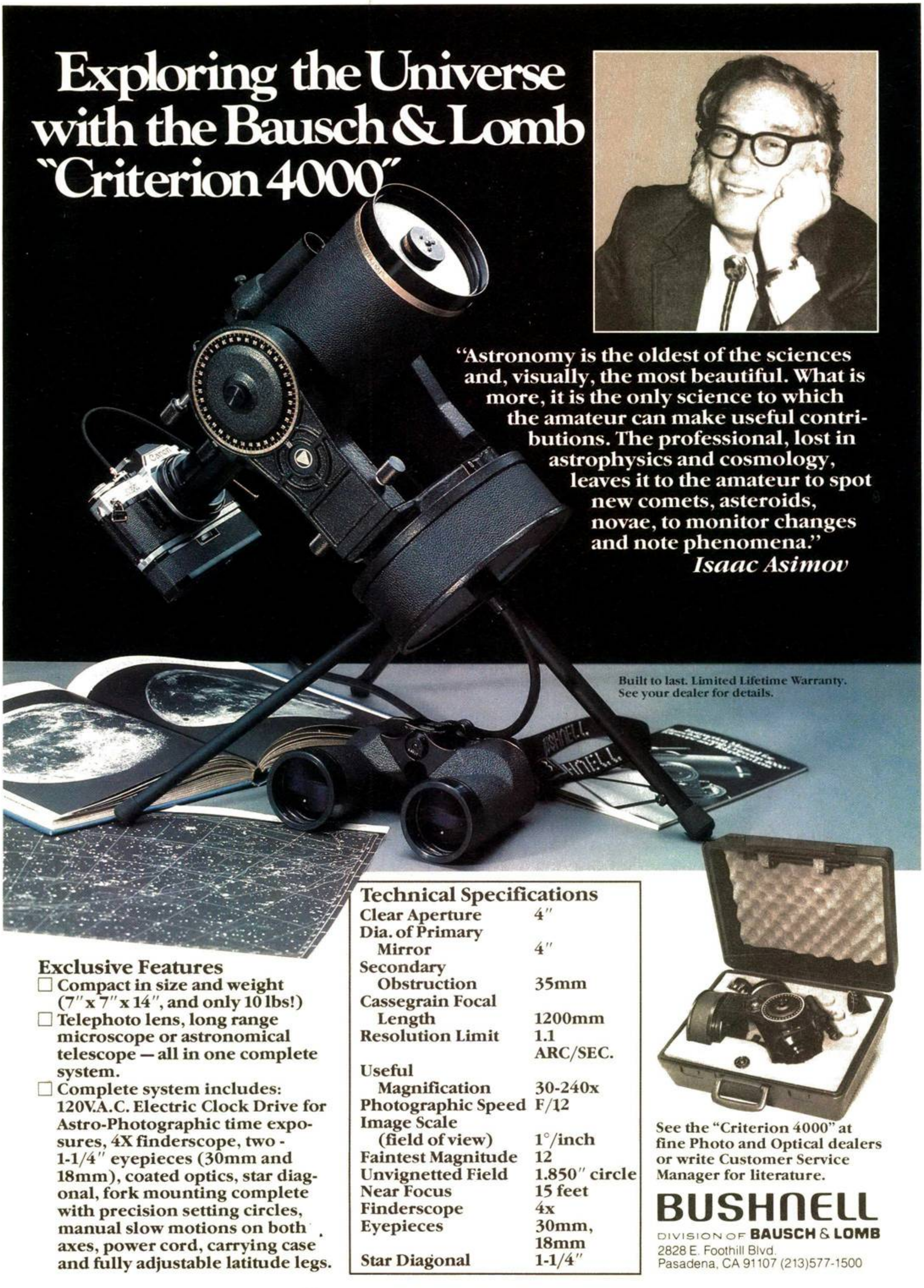
"I can stand here and tell you anything I want. No one even briefs me," he said. "Nobody has ever told me in the 20 years I have been associated with NASA — including the 10 years after I left it — anything to say or not say.

"There are no military implications other than the fact that the Shuttle was partially paid for by Department of Defense funds. Roughly a third of the payloads they fly on this vehicle over the next five years will be military. One third will be what we call scientific payloads, and the last third will be commercial applications, meaning payloads bought and paid for by industrial concerns and other people who want to use it for their own purposes.

"Some people will say, 'My Lord! That means 30% of those flights are going to be military. Isn't that terrible?'

"Well, the last year that I have figures for is 1981, and let me tell you that in that year the Russians had 126 launches into space, 107 of which were military payloads. That same year, America had 18 launches, only five of which were military payloads."

Malcolm Cheney
London, England



Exploring the Universe with the Bausch & Lomb "Criterion 4000"

"Astronomy is the oldest of the sciences and, visually, the most beautiful. What is more, it is the only science to which the amateur can make useful contributions. The professional, lost in astrophysics and cosmology, leaves it to the amateur to spot new comets, asteroids, novae, to monitor changes and note phenomena."
Isaac Asimov

Built to last. Limited Lifetime Warranty.
See your dealer for details.

Exclusive Features

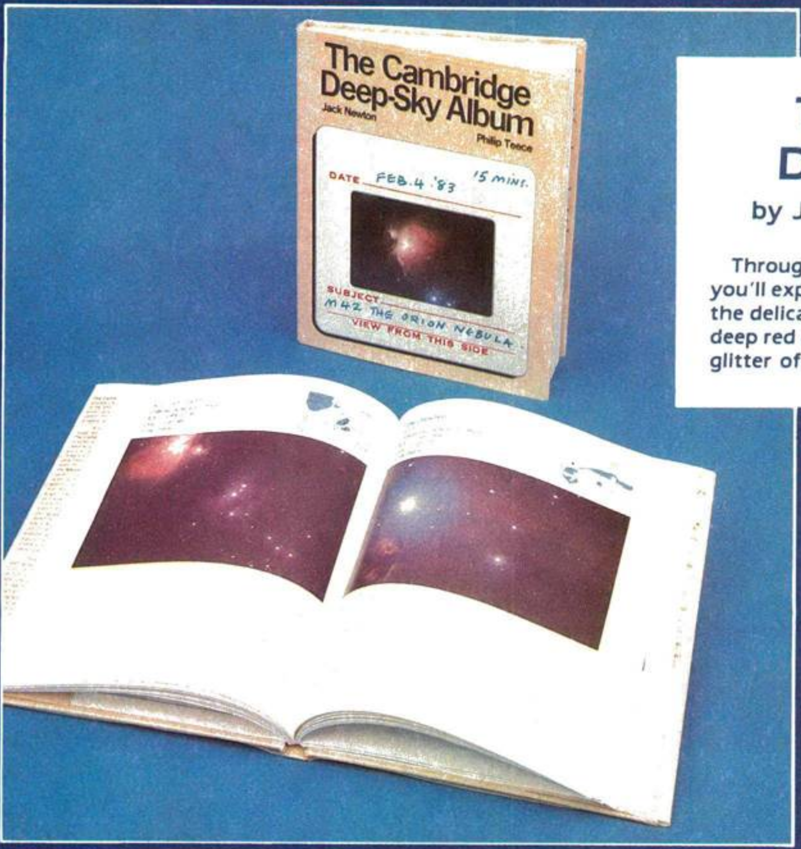
- ☐ Compact in size and weight (7″ x 7″ x 14″, and only 10 lbs!)
- ☐ Telephoto lens, long range microscope or astronomical telescope — all in one complete system.
- ☐ Complete system includes: 120V.A.C. Electric Clock Drive for Astro-Photographic time exposures, 4X finderscope, two - 1-1/4″ eyepieces (30mm and 18mm), coated optics, star diagonal, fork mounting complete with precision setting circles, manual slow motions on both axes, power cord, carrying case and fully adjustable latitude legs.

Technical Specifications

Clear Aperture	4″
Dia. of Primary Mirror	4″
Secondary Obstruction	35mm
Cassegrain Focal Length	1200mm
Resolution Limit	1.1 ARC/SEC.
Useful Magnification	30-240x
Photographic Speed	F/12
Image Scale (field of view)	1°/inch
Faintest Magnitude	12
Unvignetted Field	1.850″ circle
Near Focus	15 feet
Finderscope	4x
Eyepieces	30mm, 18mm
Star Diagonal	1-1/4″

See the "Criterion 4000" at fine Photo and Optical dealers or write Customer Service Manager for literature.

BUSHNELL
DIVISION OF BAUSCH & LOMB
2828 E. Foothill Blvd.
Pasadena, CA 91107 (213)577-1500


The Cambridge Deep-Sky Album
Jack Newton
Philip Teece
DATE FEB. 4 '83
15 MINS.
SUBJECT
M42 THE ORION NEBULA
VIEW FROM THIS SIDE

The Cambridge Deep-Sky Album

by Jack Newton and Philip Teece

Through the magic of modern astrophotography, you'll experience the thrill of deep-sky observing — the delicate blue in the arms of spiral galaxies, the deep red of glowing hydrogen nebulae, the silvery glitter of star clusters — and more.

- 136 beautiful images — all in color
- includes galaxies, nebulae and star clusters
- authoritative text and data with each plate
- objects identified by M- and NGC-numbers
- each image enlarged to uniform scale
- hardcover, 126 pages

The Cambridge Deep-Sky Album

$19.95

Foreign orders add $1.50

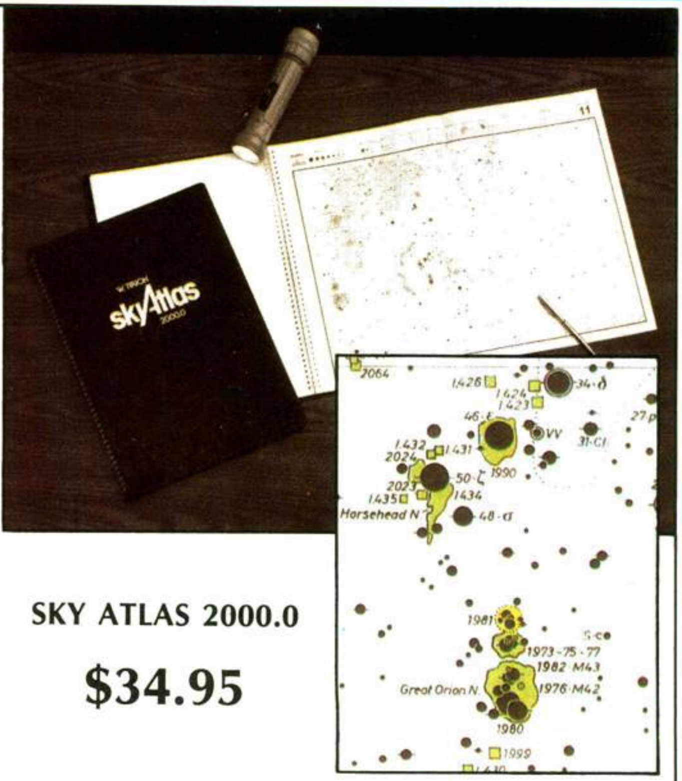
To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Sky Atlas 2000.0

Join the ranks of knowledgeable amateur astronomers with the **Sky Atlas 2000.0**. Find your way to galaxies, star clusters, and nebulae with ease. These giant star maps are crisp and distinct — and they're beautifully illustrated in color. Even the armchair astronomer will enjoy tracking down favorite nebulae and galaxies and other celestial objects seen in ASTRONOMY.

- 26 charts encompassing both hemispheres
- Each jumbo chart 12½" x 17½"
- 43,000 stars — to the 8th magnitude
- 2,500 color-coded deep-sky objects
- Clearly-defined constellation boundaries
- All Messier objects and thousands of NGC objects
- Celestial coordinates for the year 2000
- Handy reference key on each chart

Also available: **Sky Catalogue 2000.0**. 632 pages of information on over 45,000 stars — including positions, spectral type, and distance. Paperback, **$29.95.**


W. TIRION
sky Atlas
2000.0
2064
1426
1424
1423
34·δ
46·ε
1432
2024
1431
VV
31·Cl
2023
50·ζ
1990
1435
1434
Horsehead N
48·σ
1981
1973-75-77
1982 M43
Great Orion N.
1976 M42
1980
1999

SKY ATLAS 2000.0

$34.95

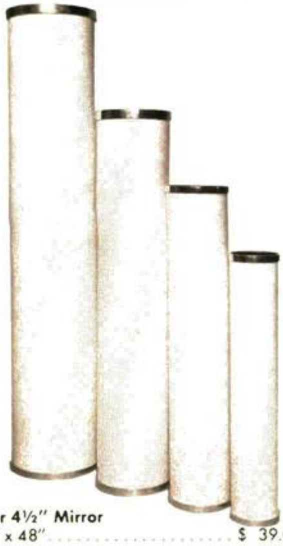
U.S. Postage included — Foreign add $2.00

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

For ALL Your Astronomical Needs

Think Quality. . .Think *PARKS*

Quality Astronomical Products Since 1954



PARKS Fiberglass Tubes

Absolutely the very best telescope tubes available. Developed and perfected in 1954 by Parks, our fiberglass telescope tubes are *simply unique in all the world.* We invite you to examine some of their unsurpassed qualities:

- ★ Virtually Indestructible
- ★ Extremely Low Thermal Conductivity.
- ★ Resists Moisture and Corrosion.
- ★ Does Not Chip or Peel.
- ★ Exterior is White Smooth Glass-like Finish, and Flat Black Interior.
- ★ Never Needs Painting, Their Color is an Integral Part of the Manufacturing Process.
- ★ Easily Sawed, Drilled or Riveted by using Commonly available tools.
- ★ Time Tested and Fully Guaranteed.

For 4½" Mirror

5" x 48"	$ 39.00

For 6" Mirrors

7" I.D. x 31" to 52"	$ 52.00
7" I.D. x 53" to 60"	$ 56.00
Anodized Aluminum end rings/pair	$ 16.00

For 8" Mirror

9⅜" I.D. x 24" to 37½"	$ 56.00
9⅜" I.D. x 38" to 55"	$ 68.00
9⅜" I.D. x 56" to 60"	$ 72.00
9⅜" I.D. x 61" to 75"	$ 80.00
Anodized Aluminum end rings/pair	$ 17.00

For 10" Mirrors

11⅞" I.D. x 40" to 48"	$ 99.00
11⅞" I.D. x 49" to 62"	$116.00
11⅞" I.D. x 63" to 72"	$132.00
Anodized Aluminum end rings/pair	$ 24.00

For 12½" or 14¼" Mirror

15⅞" I.D. x 48" to 59"	$148.00
15⅞" I.D. x 60" to 69"	$160.00
15⅞" I.D. x 70" to 79"	$170.00
15⅞" I.D. x 80" to 100"	$190.00
Anodized Aluminum end rings/pair	$ 28.00

For16" Mirror

18" I.D. x 48" to 60"	$160.00
18" I.D. x 61" to 90"	$240.00
18" I.D. x 91" to 120"	$280.00

Other Sizes Available Upon Request

Astronomical Mirrors

Our Mirrors are made from a premium quality fine annealed blank of low expansion type Pyrex #7740 with a 1:6 ratio of thickness to diameter. The optical surface is extremely smooth – no dog bisquiting. Exceptionally clean. Focal lengths ±3%. All mirrors are smooth parabolic figures without any zones or breaks. Each disk exhibits a good diffraction ring, no turned edges or edge zones. Each mirror exhibits straight Ronchi bands edge to edge under the sensitive double pass auto-collimation test. Corrected to better ±1/25th wave. Free of astigmatism. All mirrors Aluminized with silicon monoxide and Guaranteed to be of the highest quality available anywhere.

6" F/6 or F/8	$ 85.00
8" F/6 or F/7	$125.00
10" F/5, F/6 or F/7	$250.00
12½" F/5 or F/6	$395.00

Elliptical Diagonal Flats

Made of fine annealed Pryrex ±1/25th wave, aluminized. Excellent Quality

1.330"	$15.00
1.550"	$20.00
1.830"	$22.00
2.140"	$28.00
2.610"	$35.00
3.100"	$45.00

PARKS Giant Binoculars

UV coated objectives, fully coated eyepieces and prisms. Fine quality, case included
11x80, 15x80, 20x80, 30x80, $199.00 each — Tripod Adapter, $12.00

PARKS Spider/diagonal holders for:

7" I.D. tube w/1.52" holder, $25.00 --- 9⅜" I.D. tube w/1.83" holder, $28.00
11⅞" I.D. tube w/2.14" holder, $30.00 --- 15⅞" I.D. tube 2/2.60" holder, $35.00

PARKS Mounting Rings (Clamp Style, shown above)

Rolled steel rings for mounting tube assembly to saddle. Has flat base, will adapt to tube sizes other than our own. They come painted and felt lined, ready for use. For:

7" I.D. tube, a pair $50.00
9⅜" I.D. tube, a pair $60.00
11⅞" I.D. tube, a pair $70.00
15⅞" I.D. tube, a pair $80.00

PARKS Rotating Rings

Sturdy, machined aluminum fully rotating rings for Parks tubes. Ready to use. For:

9¾" O.D. tube, a pair $175.00
12¼" O.D. tube, a pair $275.00
16½" O.D. tube, a pair $325.00
18½" O.D. tube, a pair $400.00

PARKS Mirror Cells

Cast aluminum mirror cells. Quality construction throughout. For:

6" cell (for 7" to 7-1/16" I.D. tube), $20.00
8" cell (for 9⅜" I.D. tube), $28.00
10" cell (for 11⅞" I.D. tube), $35.00
12½" cell (for 15⅞" I.D. tube), $45.00

PARKS Focusers

Smooth rack-and-pinion style with positive stops at each end of travel. Adjusting system for tension. Highest quality.

1¼" – $29.00   2" – $45.00

Counterweights

Cast iron weights are 10 lbs. each, painted and are available in 1" or 1½" bore. Locking set screw holds it where you want it. $25.00

Setting Circles

Aluminum die-cast, 6" diameter, 11/16" face widths. 1" and 1½" Bore. Per pair $40.00

Illuminated Reticle (New, Compact-State-of-the-Art)

Kellner 12mm with battery pack, 1¼". Double-crossline reticle, remote brightness control. Focusable reticle. Cell Batteries included. Power cord 4'5" $49.00

Kellners Eyepieces

Performance plus a moderate price. Fully coated. Standard 1¼" and 2" threaded to accept filters. Focal lengths:
1¼", 6mm, 12mm, 25mm, 40mm. $22.00
2", 50mm, 60mm. $59.00

PARKS Ortho-scopics

We offer a truly excellent 4-element design Orthoscopic eyepiece that gives high resolution and color correction. Fully coated for maximum light transmission. Sharp 45° apparent field of view. Standard 1¼" threaded barrels.
f.l. 5mm, 6mm, 12.5mm, 25mm.
$33.00

PARKS Erfles

Multi-coated, top quality eyepieces. 65° designed for breathtaking wide field observing with maximum eye relief.

1¼" - 20mm, 32mm – $45.00   2" - 32mm – $85.00

PARKS Plossls

Exquisite optics in a true Plossl design, ultra-high contrast parfocal, multi-coated, wide field with exceptional eye relief. 6mm, 9mm, 12.5mm, 18mm, 25mm, $49.00 40mm, $59.00

PARKS Barlows

Full 26mm aperture, doubles the power of any eyepiece while maintaining excellent image quality. Designed to yield professional performance. $29.00

PARKS Photo-Visual Color Filters

Excellent high quality photo-visual color filters made of top quality Hoya glass. Spectrum is homogenized as in 35mm camera filters, magnesium flourite coated for maximum light transmission. Threaded on both ends for use with 1¼" O.D. eypiece and to use filters piggyback.

#8 light yellow, #11 yellow green, #12 yellow, #15 dark yellow, #21 orange, #23A light red, #25 red, #56 green, #80A medium blue, #82A light blue, #29 dark red, #38A dark blue, #58 dark green, Polarizer 30% $10.00

PARKS Nebular Filter (LPB)

Light pollution reduction filter for blocking mercury and sodium light pollution. Brings the country skies to your backyard. Threads into 1¼" eyepiece. $49.00

PARKS Viewfinders

An excellent large aperture finder. Features coated achromatic optics, crosshair reticle helical type focusing for precise images. Not of the hit and miss push/pull type.

8x50mm Straight thru model	$45.00
8x50mm Right angle model	$49.00
Mounting brackets	$12.00
6x30mm 7° Straight thru model w/bracket	$30.00
6x30mm 7° Right angle model w/bracket	$35.00

PARKS 2.4" Refractor Guidescope

For your photographic applications we offer a top quality 2.4" refractor guidescope (D=60mm, F=700mm)
Fully-coated objective lens, rack-and-pinion focusing, star diagonal prism, and H 35mm eyepiece. $69.00
Two ring mounting brackets $12.00/pair

PARKS Heavy-Duty Equatorial Mount

PARKS heavy-duty equatorial mount shown above with 10" tube assembly. The massive equatorial head is cast of virgin aluminum and machined precisely to exacting tolerances. Timpkin tapered bearings mounted on polar shaft assure trouble-free performance. Steel pier of 6½" diameter with heavy wall gives rigidity necessary for photographic applications. Steel shafts are 1½" diameter. Three heavy-duty steel pier legs and two 10lb. counterweights included. Saddle plate adaptable to any size tube or can be used with multiple tube sizes. Complete as described, $450.00.

PARKS Telescope Co.
676 Easy Street, Dept. A
Simi Valley, California 93065
Phone: (805) 522-6722

TO ORDER: Send your request with a Check or Money Order in the amount listed above. Calif. residents add 6% Sales Tax. Tubes and Equatorial Mounts, shipped freight collect. We pay shipping and insurance on all other merchandise in Continental U.S. C.O.D. and Credit Card holders call Toll Free (800) 235-3344 (order line only), in California call (800) 847-2673. For information call (805) 522-6722.
SATISFACTION GUARANTEED. Return merchandise within 15 days for full refund if you are not 100% delighted.

ASTRONOMY
In Focus

Old Comets

Sir / Paul Casdorph's letter in the November 1983 issue can be answered by the *Catalogue of Cometary Orbits*, by Brian Marsden (Enslow Publishers, Hillside, New Jersey). It shows that only one comet was observed in 1859 (Comet Tempel), and its last sighting was July 1, 1859. The next comet observation was Comet Liais, first sighted February 27, 1860. Thus no comets were observed and reported during the close of 1859.

Michael Ferrio
Charlestown, RI

Binary Confusion

Sir / In Stephen Gillett's article, "Possible Planets" (February 1984), he states that a binary star system in which the stars are separated by about 10 AU (such as the two main members of the Alpha Centauri system) is the worst case for planetary formation. Yet Paul Patton, in his article "The Three Suns of Centaurus" (January 1982), writes that Stephen Dole of the Rand Corporation determined that planets can have stable orbits around each of these stars, and that the stars are far enough apart to have their own ecosphere. He adds that this star system may have as many as four separate planetary systems. Who is right?

Mark MacKinnon
Bangor, ME

Mr. Gillett replies:

No one knows yet who's "right" on the subject of extrasolar planets because we have so little hard data. All we have are various lines of evidence indicating what may occur — and the hypotheses suggested are by no means necessarily in agreement!

In this case, however, the questions are somewhat different: I addressed the case of planet formation *in a binary star system, not the question of whether stable planetary orbits could exist in such a system. Dole is quite correct in that planets could have stable orbits in the Alpha Centauri system. But it's not at all clear whether planets could form there to begin with. Some recent theoretical work suggests that planetary formation is very sensitive to gravitational perturbations.*

Thomas Heppenheimer, writing in Astronomy and Astrophysics *(vol. 65, 1978), investigated the theoretical behavior of planetesimals in a binary stellar system. His work suggests that in most cases the orbits of the planetesimals are so stirred up by stellar perturbations that they never collect into planets. In fact, it looks as though in our own Solar System the perturbations from Jupiter significantly affected the growing planets, even though Jupiter has only 0.1% of the Sun's mass. (Jupiter and the other gas giants probably accreted much more rapidly than the rocky inner planets — just as the Sun itself did.) Compared to Earth, Mars is relatively small, and Heppenheimer attributes this to Jupiter — it perturbed away planetesimals that otherwise would have been incorporated into Mars. If this is true, Jupiter's effect was far-reaching indeed, because the mean distance of Mars from the Sun is only about 1.6 AU, whereas Jupiter lies at 5.2 AU — more than three times farther out.*

To get around these perturbation effects in a binary system, the growing protoplanet either has to be so close to one star that the gravitational effects of the other are swamped, or else the stars must be extremely close together, so they essentially act as a single body that the protoplanets can circle.

None of this is yet "proven" in any absolute sense. We just don't have much data — all we have is some simple theoretical models that may or may not reflect the important parts of a very complicated physical system. The research of George Wetherill provides an example of the uncertainties involved. He performed computer simulations of planetary accretion at the Jet Propulsion Laboratory in California, and he found that the planetesimals need some *perturbations in order to accrete. Otherwise, they don't get swept up efficiently, and the result is a planetary system containing many small terrestrial planets rather than four or five large ones. To my knowledge, Wetherill has not extended his work to binary systems to find the point where perturbations cease being helpful and become destructive. Wetherill has summarized his work in an article in the June 1981 issue of* Scientific American.

To know for sure whether planets exist in binary systems, we need observational data — which, alas, will not be forthcoming for some time!

Fiber Optic Star Map

Sir / Thank you for the fine star map on pages 36-37 of the March issue! I have used it as a pattern for drilling a set of holes into a piece of matte-black Masonite, with each hole sized according to the star's magnitude. (I hit every star, both in the constellations and in the Milky Way.) After drilling the holes, I fitted each with an appropriately sized fiber optic strand and then gathered all the fiber optics for each "magnitude" and lit them with a light whose brightness varied according to the magnitude.

For the lines between the stars which depict the constellations, dark blue fiber optics of the smallest size (0.0135") spaced half a millimeter apart and on a different circuit did the trick nicely; galaxies and clusters are picked out in red. Thus, by pressing the appropriate switch I can light up each constellation or deep-sky object.

I'm now going to rig lights to make the winter map (in the December '83 issue) and am looking forward to the summer and fall installments when they appear.

George P. Miller
Alameda, CA

Mr. Miller — wait 'til you see the north and south circumpolar star maps, too. Don't retire your drills yet!

Clocks and Calendars

Sir / The letter from Fred C. Davis, Jr., in the March issue of ASTRONOMY, regarding the article "Clocks and Calendars for Astronomy" (January 1984) is wrong on two counts.

Julius Caesar *did* introduce a calendar in 45 B.C. with seven 31-day months, four 30-day months and one 28-day month. Mr. Davis is wrong in suggesting that the Julian calendar comprised six 31-day months, five 30-day months and a regular February with 29 days.

The month we now call "August" was named after Emperor Augustus in an edict of 8 B.C. Its earlier name was "Sextilis," not "Sextember," as Mr. Davis thinks.

The old Roman calendar was made up of four 31-day months (March, May, July, and October) and seven 29-day months, because of a superstitious avoidance of even numbers. Only February, being the month devoted to the worship of the dead, had an even number of days (28). That made a year with 355 days. An intercalary month was added in February every other year or so. Because of the inconveniences of the system, Caesar reformed the calendar in 45 B.C. and introduced for the first time the concept of 30-day months. He added 10 days in all, to make a year of 365 days. February remained with its 28 days, with the provision of an extra day added to it every four years. This extra day was taken to be a duplication of February 24, the sixth day before the Calends of March, hence the name "bissextile."

Now, after Caesar's death in 44 B.C., the pontifices started introducing this extra day every three years instead of every four. This went on for 36 years, in the course of which the calendar accumulated three days too many ($^{36}/_{3} - {}^{36}/_{4} = 3$). So Emperor Augustus published an edict in 8 B.C. suppressing leap years for the next 12 years in order to get rid of the three unwanted days. (The same edict conferred to the month "Sextilis" its present name of "August.") So after 4 A.D. everything fell back into place and the Julian calendar ran an uninterrupted course until October of 1582, when Pope Gregory XIII made two changes: he introduced a scheme that dispensed with leap years every 400 years, and changed the traditional second February 24 in a leap year to February 29.

For the historical sources that back up these assertions, please refer to my recent book *Le Calendrier Romain* (1983, 384 pages), University of Ottawa Press, Ottawa, Ontario, Canada K1N 6N5.

Pierre Brind'Amour
Nepean, Ontario

Iron, the Heavenly Metal

Sir / In the April ASTRONOMY, a letter on meteorites by Dr. W.F. Duerfeldt caught my interest.

It was not until the 13th century B.C. that iron became common in the ancient world. However, the metal was not unknown in the early centuries of even the third millennium B.C. This is shown by tools found in Egypt embedded in two Fourth Dynasty pyramids, as well as by iron implements discovered in Mesopotamia.

The earliest iron objects found are usually pieces of jewelry from tombs of periods for which no written records exist. They are of meteoritic iron fashioned by beating. (That the iron is meteoritic is proved by its nickel content.) In ancient Egypt as well as in Sumeria the name for iron was "heavenly metal," which also indicates a meteoritic origin.

Sister Damian
Carmelite Monastery
Salt Lake City, UT

Ooops!

In the table on page 51 of the May issue, each of the two f/stop and shutter settings in the last line under ISO/ASA 100-125 should be shifted one column to the right; under ISO/ASA 200-250 and 400-450, the last *two* lines should be moved one column to the right. The photo on the June cover should be credited to the Anglo-Australian Telescope Board.

Behind
the Scenes

Shopping in AstroMart

At last year's AstroFest, one of the participants cornered me and confided, "I really hope you guys keep running all those little ads in AstroMart forever. I've gotten more good stuff there than you'd believe; it's one of my favorite parts of ASTRONOMY."

I assured him that we have no intention of eliminating any part of AstroMart. It's not only a fine place to shop for a new telescope, but a fine place to pick up used (or "hardly ever used") equipment at great prices. It's there that you'll see display advertisements from companies who can coat your telescope mirrors with high-reflectivity silver, sell you a hard-to-find book, or make you a sidereal clock. In addition, we're proud to offer free space in AstroMart for announcing local and regional events and meetings that don't qualify for the AstroCalendar section at the end of AstroNews.

Listings — the little ads — are free to all our readers. We don't charge for them, but we do expect people to play by the rules. You get two listings per year. They must be ANNOUNCEMENTs for meetings or activities, FOR SALE items that are one of a kind, or WANTED notices. Listings are strictly non-commercial. And, of course, we reserve the right to review them for suitability.

To have a listing for yourself or your club, simply send a letter — even a postcard — with your announcement on it. It really helps if you print, rather than write — or better yet, type. Please don't abbreviate; sometimes notices are so cryptic we can't figure out what you mean. We'll put in abbreviations or shorten the listing if we think it's necessary.

On another topic, enough readers asked us whether they could download computer programs, such as April's SUNNY.BAS program, that we looked into how we could accommodate your requests. As a result, we have become subscribers to the CompuServe Information Service, and will place the programs we run in ASTRONOMY in the Public Access area. You or a friend of yours with a modem and CompuServe password can then download programs at your convenience. (Your friendly local computer store probably sells CompuServe Starter kits for about $40.) If you're not "into computers," don't worry about any of this stuff. It's not really necessary to enjoy ASTRONOMY.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

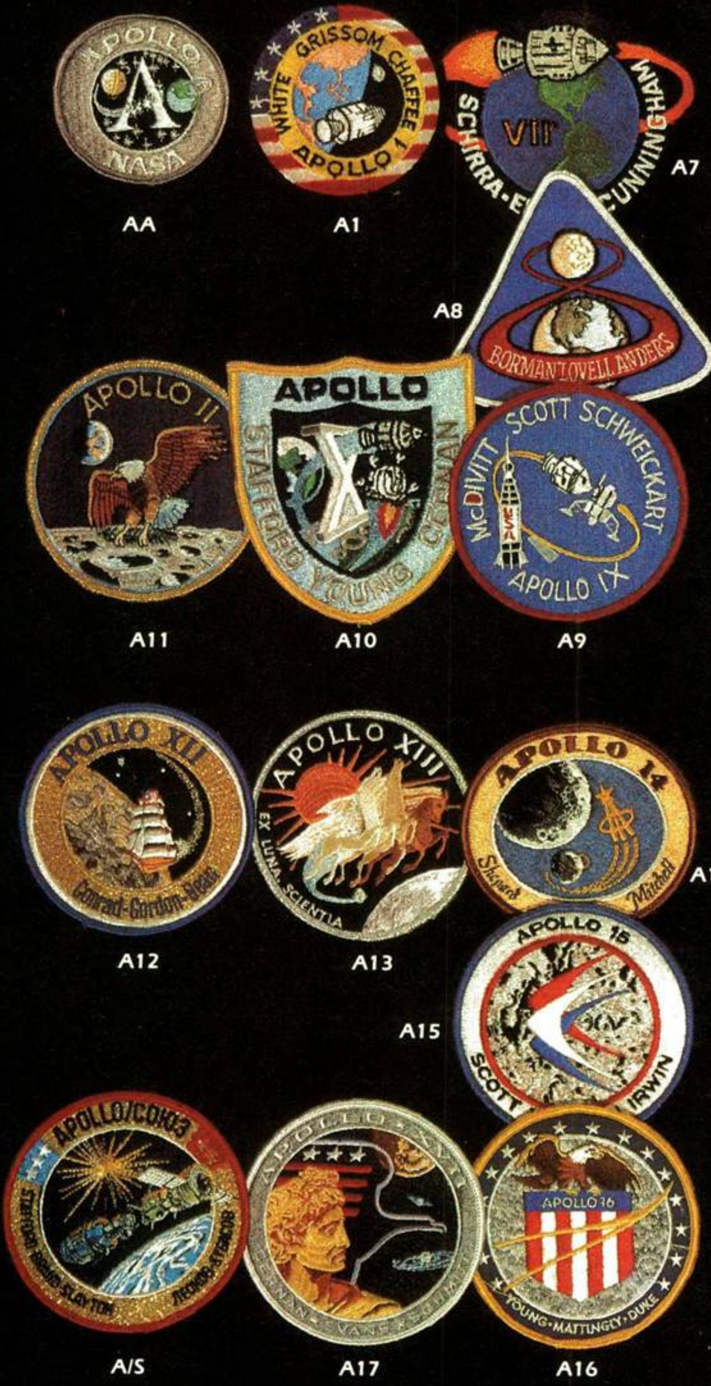
NASA Emblems

**from ASTRONOMY
Manufactured by the Official
NASA Supplier**

Wear these historic colorful patches on your jacket or cap, or display them in frames — either way you'll be proud to show them.

APOLLO MISSION

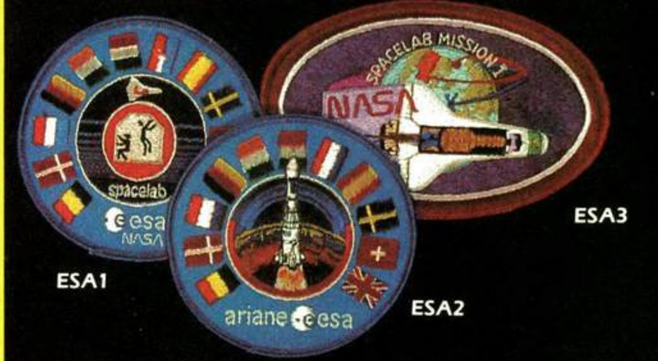
**4" each, $4.95 each. (AA, 3", $3.49)
Set of 14 Apollo — $39.95**


APOLLO
NASA
WHITE GRISSOM CHAFFEE
APOLLO 1
SCHIRRA EISELE CUNNINGHAM
VII
BORMAN LOVELL ANDERS
APOLLO II
APOLLO
STAFFORD YOUNG CERNAN
X
McDIVITT SCOTT SCHWEICKART
APOLLO IX
APOLLO XII
Conrad-Gordon-Bean
APOLLO XIII
EX LUNA, SCIENTIA
APOLLO 14
Shepard Mitchell
APOLLO 15
SCOTT IRWIN
APOLLO/SOYUZ
STAFFORD BRAND SLAYTON
APOLLO XVII
APOLLO 16
YOUNG MATTINGLY DUKE

AA A1 A7
A8
A11 A10 A9
A12 A13 A14
A15
A/S A17 A16

ESA MISSION

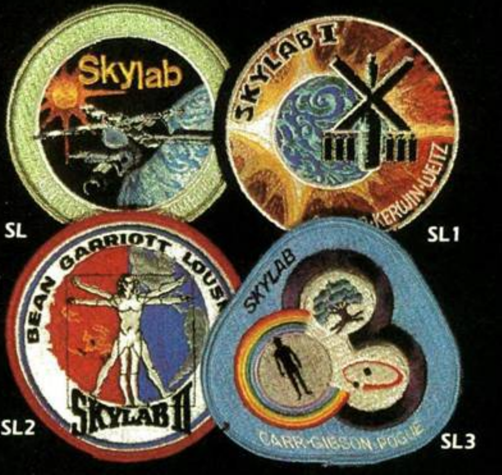
**4" each, $5.49 each.
Set of 3 ESA — $11.50**


spacelab
esa
NASA
SPACELAB MISSION I
NASA
ariane esa

ESA1 ESA2 ESA3

SKYLAB MISSION

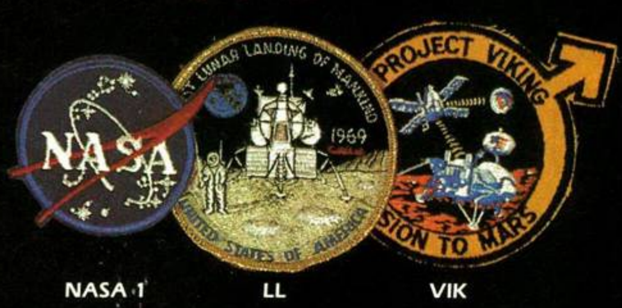
**4" each, $4.95 each.
Set of 4 Skylab — $12.95**


Skylab
SKYLAB I
KERWIN WEITZ
BEAN GARRIOTT LOUSMA
SKYLAB II
SKYLAB
CARR GIBSON POGUE

SL SL1
SL2 SL3

PLUS

**NASA 1, 3", $3.49
LL, 4", $4.95
VIK, 4", $4.95**


NASA
LUNAR LANDING OF MANKIND
1969
UNITED STATES OF AMERICA
PROJECT VIKING
MISSION TO MARS

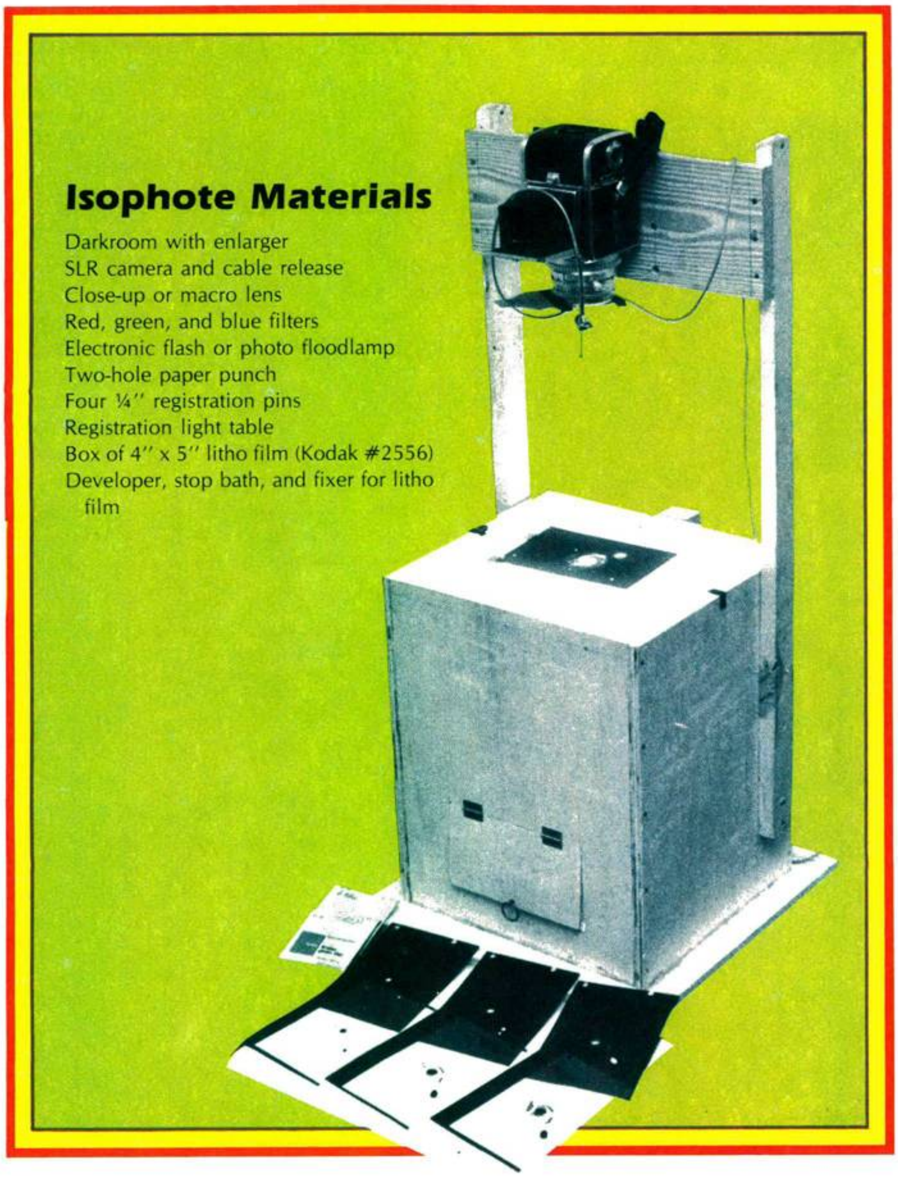
NASA 1 LL VIK

To order, specify the patch code or set name on the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202

Isophote Mapping

Photography in Astronomy

by
Joseph Macrie



A registration light table equipped for isophote mapping. The frosted glass surface accommodates negatives and positives, which are backlit by a flash (note trap door) and photographed onto color slide film in the camera on top. All photos by Joseph Macrie.

Isophote Materials

Darkroom with enlarger
SLR camera and cable release
Close-up or macro lens
Red, green, and blue filters
Electronic flash or photo floodlamp
Two-hole paper punch
Four ¼" registration pins
Registration light table
Box of 4" x 5" litho film (Kodak #2556)
Developer, stop bath, and fixer for litho film

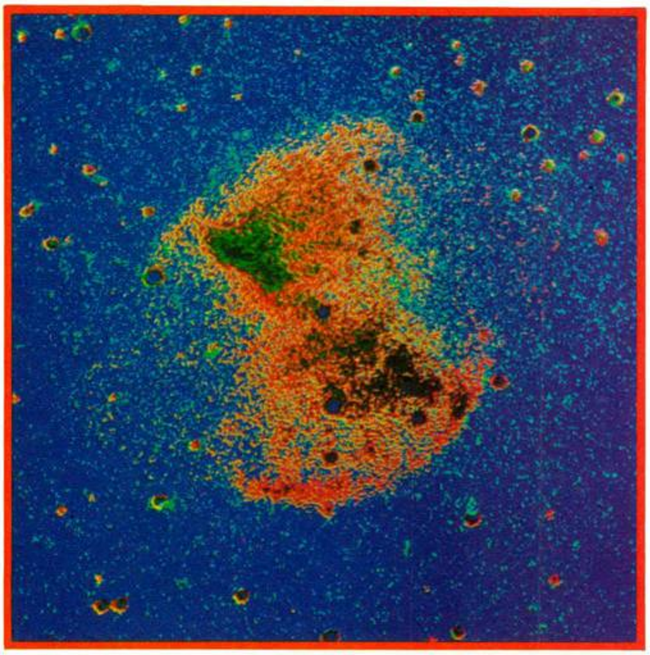
A photograph of a galaxy or a nebula records an awful lot of information — about 10 million bits on a typical black and white frame! As technology has improved over the last couple of decades, astronomers have looked for ways to manipulate the image to extract the most usable information from an exposure. Nowadays professional image processing requires elaborate computer software or complex darkroom trickery. However, a relatively simple technique called isophote mapping produces snazzy computer-like images and reveals useful information about celestial objects. "Isophote" simply means "equal light" — which offers a clue to what it involves.

This technique separates regions of differing intensity by using a lithographic film, which responds to light by staying clear with exposures below a certain level, and turning solid black above that level. There are no tones in between. By rephotographing a litho film outline through a color filter, you can make that region of equal intensity easily identifiable because it shows up as a single color. Repeating the process for a series of different intensity film, you can build up multicolor images — isophote maps.

Constructing a Light Table

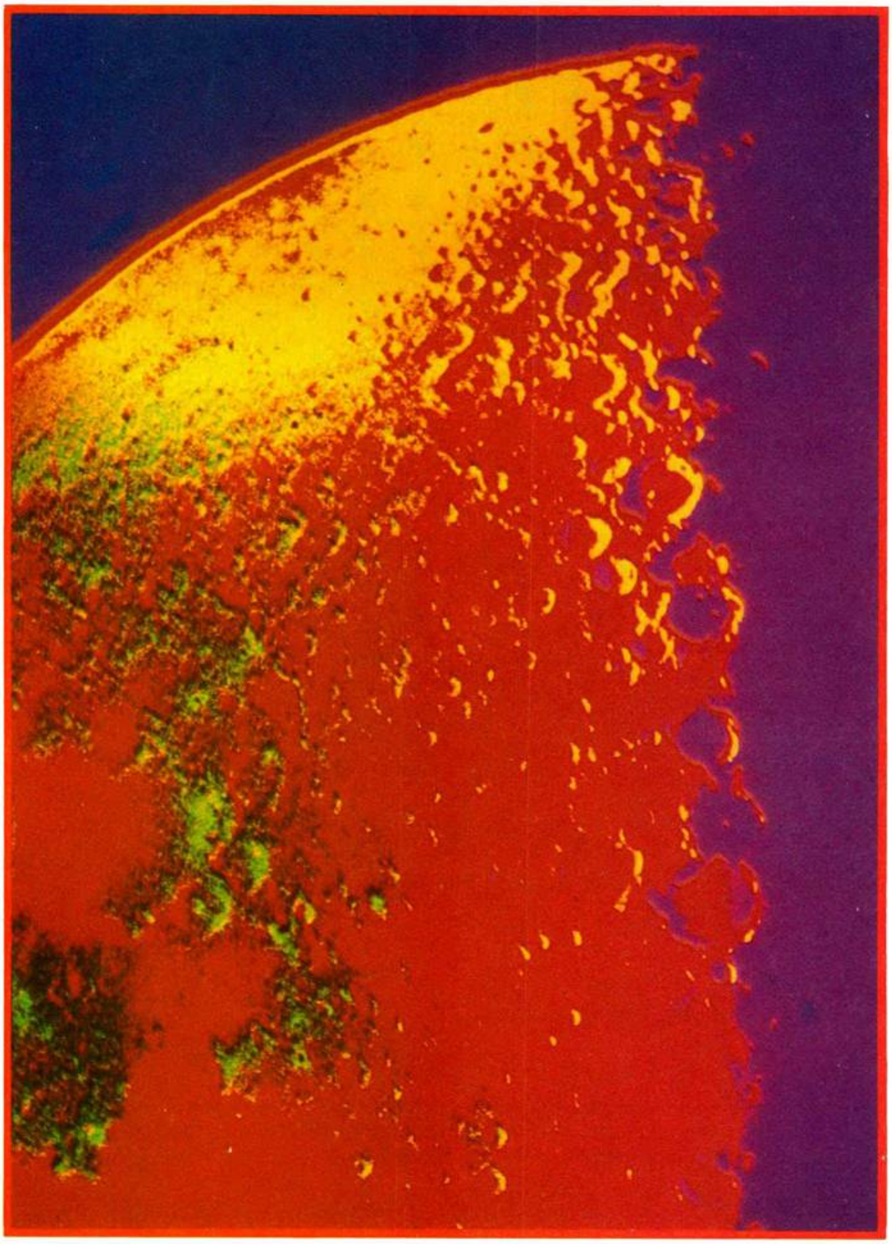
In addition to standard darkroom gear, your camera, a set of color filters, and a box of Kodalith #2556 or equivalent litho film, you'll need to build or acquire some simple equipment — the largest item of which is a light table for registering negatives. Constructing one is relatively simple. I made mine out of ½" scrap plywood and a 12" square piece of frosted glass. The table consists of a box, measuring 12" x 12" x 18", with 2 x 4s bolted on two sides to accommodate a camera mount. The camera sits about 18 inches above the frosted glass surface. The box has a small door on its front, which allows me to insert an electronic flash, and a hole through which the flash cord can pass up to the camera.

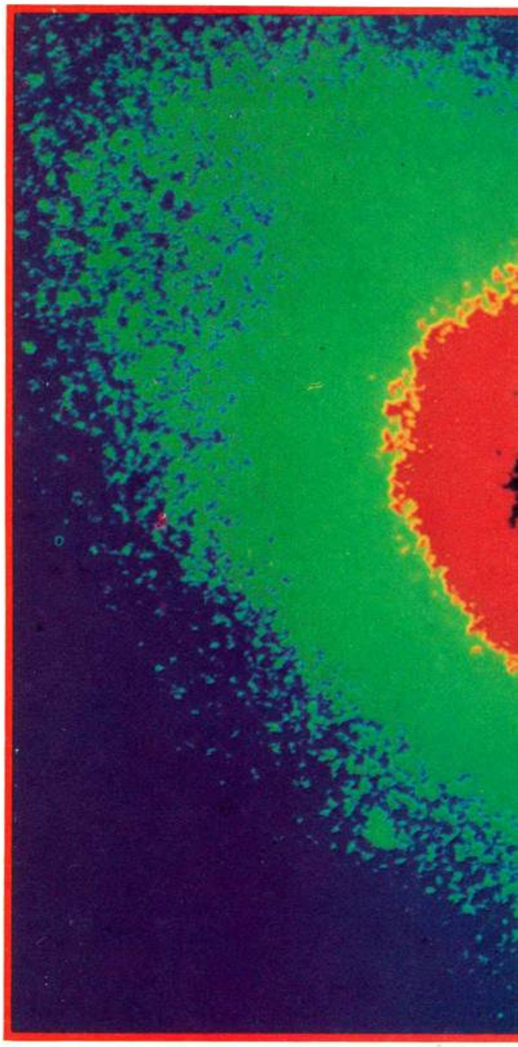
My flash is a Vivitar #283 with a guide



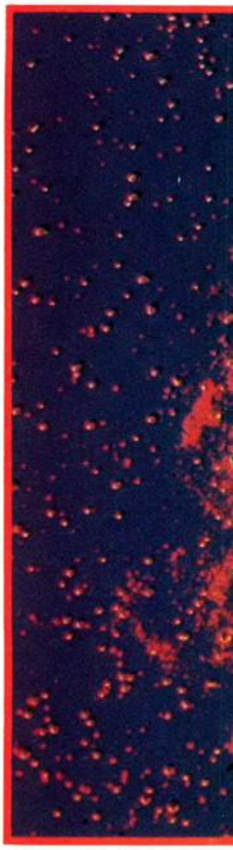
Left: Delicate nebulosity of the Dumbbell Nebula appears flesh-colored in this 30-minute exposure on 103a-F made at f/7 with an 8-inch SCT. The regions of greatest intensity appear as green and red; the Dumbbell's 13th magnitude central star is dark blue.

Below: The lunar highlands take on a pop-art look in this 8-inch SCT eyepiece projection photo made originally on Tri-X. The brightest areas appear yellow, while dimmer regions look green and red. The sky itself is colored violet.

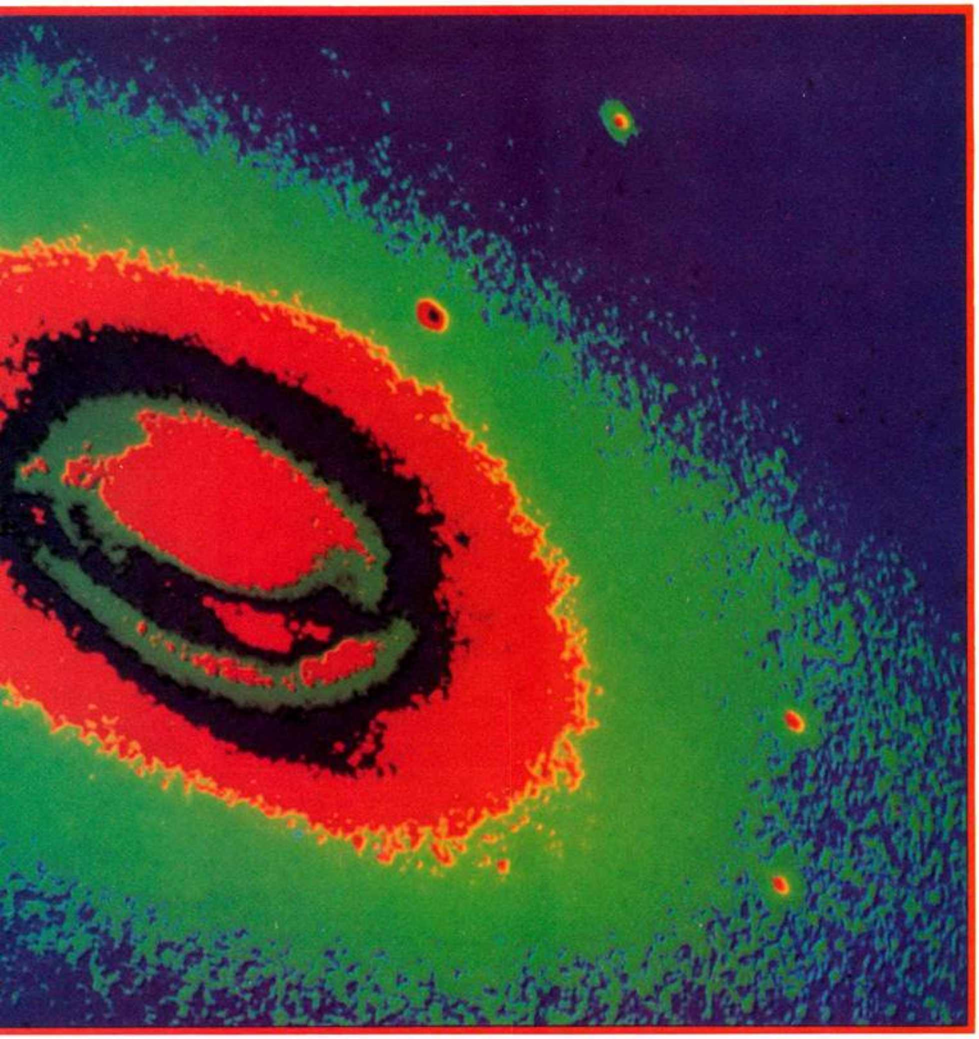


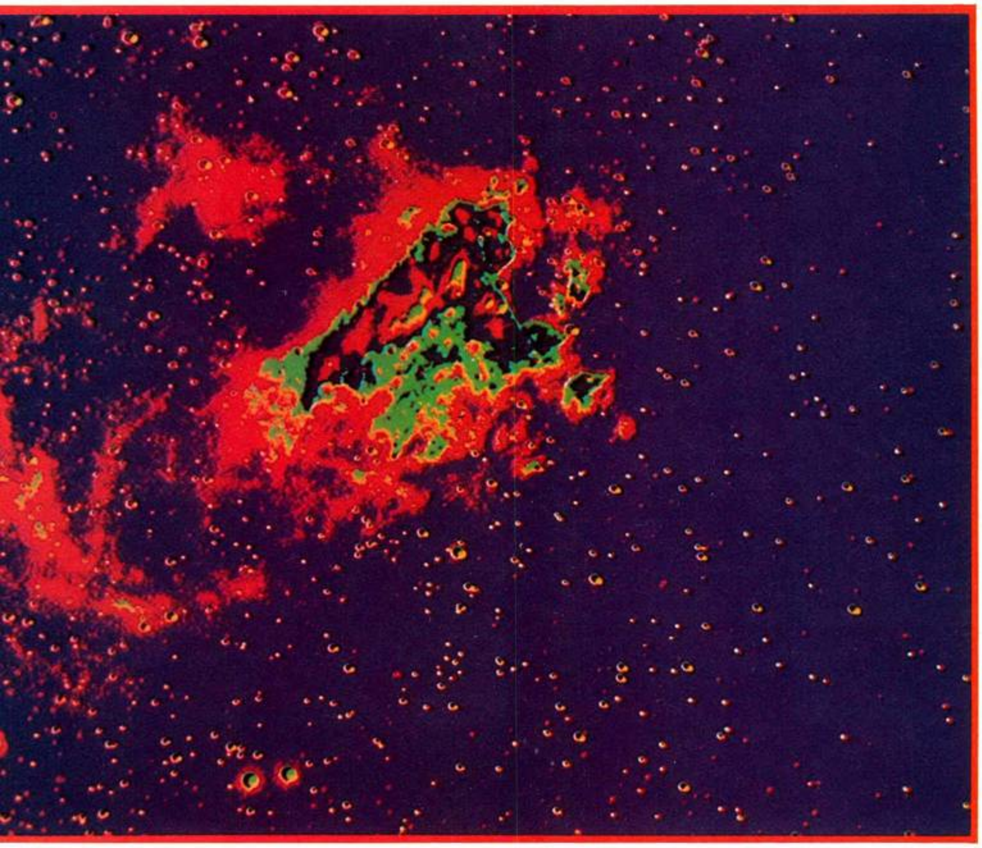


Above: A 60-minute exposure with the 8-inch f/7 SCT, made on hypersensitized TP 2415, reveals six intensity levels in the Blackeye Galaxy, M-64, in Coma Berenices. The bright areas including the core appear red; the galaxy's obscuring dust band shows up as blue.



Right: A complex and ornate nebulosity in Sagittarius, the strangely shaped Omega Nebula lies in a rich starfield. Macrie made this 45-minute exposure with an 11-inch f/7 SCT and hypered TP 2415.





number of 120 with ISO 100 film. Flash provides consistently good color balance and even lighting, and allows me to stop down to f/16, yielding sharp star images to the very edge of the frame. At the distance of 18 inches, shooting Kodachrome 64 and using red (Wratten #25), green (#58), and blue (#47) filters, exposures of 1/60 second at f/16 work well. (You'll probably want to get these three standard filters, but you can use any colors you like.) Normally with filters, exposure factors should be taken into account, but I've found this unnecessary.

If your camera lets you make 1:3 macro photos, you're all set. If it doesn't — which is most likely the case — you'll have to get a bellows plus a close-up lens or a macro lens, either from your local photo store or a mail-order house (see the photo magazines). Together these items will probably cost $125 or so, a reasonable investment considering how many nifty photos you can make with it.

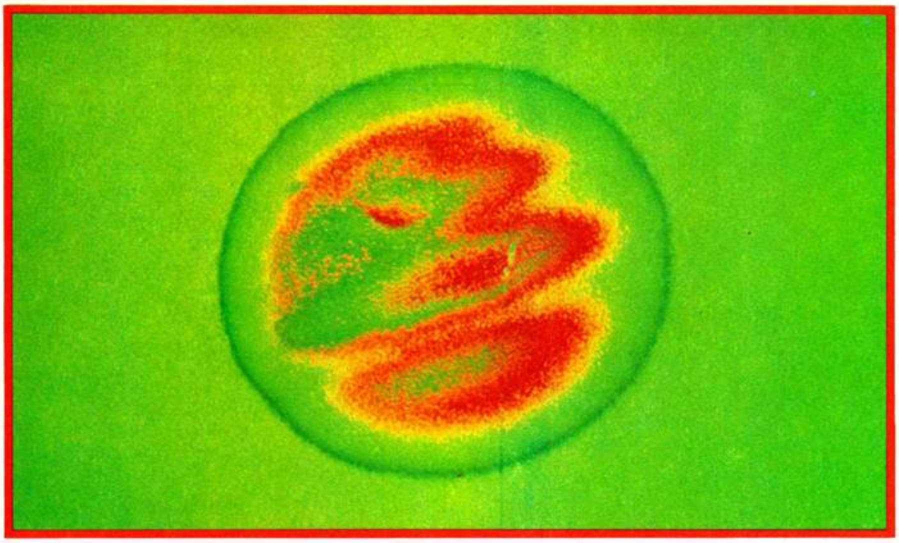
For registering films on the light table, get some registration pins from your local photo or art supply store (the standard convenient size is ¼"). You'll tape these down on the table at the proper spacing, to guarantee that each piece of film fits exactly into the same spot every time. To make holes in the film, you need a two-hole punch. But beware — most standard hole punchers make holes larger than the register pin size. Check before buying to see that the pins fit the punch holes.

Making the Positives

The first step in making the positives is to insert your original negative into your enlarger. Cut a 4" x 5" piece of white cardboard, and make two holes in the longer side with the punch. Insert the registration pins with their tabs protruding outward from the edge of the cardboard. Place the cardboard on the enlarger's baseboard, focus, and compose your image within the 4" x 5" area. Once this is done, tape the tabs of the registration pins securely in place. Now, remove the 4" x 5" cardboard and stop down the enlarger's lens to f/11; take care not to disturb either the enlarger or the baseboard. Turn off the white lights and turn on the darkroom red safelights.

Remove 11 sheets of 4" x 5" lithographic film from the box (don't worry — this film isn't sensitive to red light). Punch holes through one sheet at a time, at the same end, emulsion side up, just as you did with the 4" x 5" white cardboard. (The emulsion side of litho film appears lighter than the other side under a safelight.) Try to keep the holes about the same distance from the edges of the film; this isn't critical, though, as the holes themselves will govern registration.

Now put all but one sheet of film back onto the storage box. Place this 11th sheet onto the registration pins of the enlarger baseboard, emulsion side up. You'll use this sheet as a test strip to determine your correct exposure. Use a piece of opaque cardboard to cover all but about one inch



Left: Can you guess what this is? It's Jupiter — photographed on Tri-X with an 8-inch SCT. The brightest belts and zones appear red; slightly darker ones are yellow.

Resources for Isophote Mapping

Creative Darkroom Techniques, 3rd ed., Kodak
The Joy of Photography, Addison Wesley
More Joy of Photography, Addison Wesley
Images, Images, Images, Kodak
Black and White Darkroom Techniques, Kodak

of the film. Make a five-second exposure, then slide the cardboard so another inch of the film is uncovered and make another five-second exposure. You can get five steps on the sheet of film, with test exposures running from 5 to 25 seconds.

Now develop, fix, and wash this test strip according to the manufacturer's instructions. Once fixed, choose the exposure time that just prints the clear area of the original negative (i.e., the sky) as black for your "starting point exposure." In my enlarger, the starting point exposure is about five seconds at f/11.

Now remove one of the previously punched sheets of film from the storage box and use your determined starting point exposure for your first positive. Continue by doubling the exposure time for the remaining four positives that you will need. For example, my starting point exposure was five seconds at f/11 for positive #1.

Positive #2 will be 2 x 5 seconds = 10 seconds.
Positive #3 will be 4 x 5 seconds = 20 seconds.
Positive #4 will be 8 x 5 seconds = 40 seconds.
Positive #5 will be 16 x 5 seconds = 80 seconds.

Develop, fix, and wash all positives the same as your test strip. Now you can work under white light again. Once the positives are dry, scratch a small letter — A, B, C, D, or E — on the emulsion side for later identification.

Making the Negatives

Without disturbing the enlarger, remove the original negative and replace the carrier. Turn off the white lights and turn on the red safe lights. With the enlarging lens still at f/11, use the enlarger's baseboard and registration pins to contact-print each of the positives with the remaining punched lithographic film, emulsion to emulsion. I usually wipe my hand gently over the two films to build up a static charge that holds them in good contact. A better way would be to lay a piece of clean glass from a picture frame on top of them.

The exposure time for these contact negatives should be about four times the starting point exposure. In my case, since the starting point exposure was five seconds, the exposures for the contact prints should then be 20 seconds at f/11. These negatives should be developed, fixed, and washed in the same manner as the positives. At this point, you have a matching set of five high-contrast negatives and positives lettered A, B, C, D, and E. These will now be used to produce the final color isophote.

Making the Color Isophotes

This is where the light table comes into play. First, load your camera with color slide film. I like Kodachrome 64 because it has little grain, good color, and it works well with my flash guide number and copy distance. Attach your camera with macro lens, or bellows plus close-up lens, to the crossbar of the table. Plug in the flash, attach your cable release, set the shutter speed, and stop the lens down. On your first roll, bracket exposures between f/11 and f/22. Now set your camera on multiple exposure mode (check your camera's manual).

Next, place registration pins in the holes of negative A, then place negative A, emulsion side down, on the light table. Focus and compose your image in the camera, then tape the tabs of the registration pins to the frosted glass. Negative A will be used for the background or "sky color" of your isophote. The background in negative A is clear, while the object's area is black. This negative will hold back light from the object while exposing the clear or background sky.

For this example, photograph negative A with the blue filter. Re-cock the shutter (or with non-multiple-exposure cameras cover the lens with a lens cover) and continue by replacing negative A with positive A (emulsion side up) and negative B (emulsion side down). Cover with clean glass for a good contact. These will print the very weak nebulosity or faintest part of the isophote; use a red filter for this one. Positive B (emulsion side up) and negative C (emulsion side down) will print weak parts of the isophote, so let's use a green filter here. Positive D (emulsion side up) and negative E (emulsion side down) will be used to print the strong and dense parts of the isophote. Try the red filter again. Positive E (emulsion side up) will be used to print the core or brightest areas, such as the brightest stars. This time use the red and green filters.

If your camera lacks multiple exposure capability, you can still use the light table: put a lens cover over the camera lens, set the camera shutter speed on B, for bulb, and lock the shutter open with a locking cable release. Then to make a series of exposures on the same frame, turn off the lights, remove the lens cover, trip the flash by shorting it out at the PC connection with a small metal object, and recover the lens. (Remember to keep the room totally dark when the lens cap is off!) Continue this procedure until you have completed your series of exposures for that frame. Then release the locking cable release and advance the film.

Once you have finished your exposure sequence for this isophote map, advance your film to the next frame and try some other filter/negative/positive combinations. For instance, photographing positive A with red and blue filters will produce magenta. Combining positive A with negatives B, C, D, and E will give still another look to your finished isophote. Once you have finished exposing the roll of film, have it processed normally.

When you get your slides back from the processor, you will have a variety of stunning color combinations — some good, some bad, some simply weird. Note which color combinations worked best. Even lackluster original negatives can be transformed into beautiful graphic representations that also convey useful information about the object. In the never-never land of astrophotography, that's an outstanding bargain — the best I've ever had!

ASTRONOMY
Reviews

A Hundred Billion Suns

Mario Rigutti
285 pages, hardcover, $25.00
MIT Press (1984)

This is a curious book.

It was originally published in 1978 in Italy by a distinguished Italian astronomer who wanted to write a volume that would help meet the "conspicuous lack of professional work in the popularization of astronomy" in his country. To do this he has limited his scope to the origin, nature, and end of stars — ignoring galaxies and extragalactic phenomena, and only briefly touching on the inner solar system (the outer planets had not yet been well explored by spacecraft at the time he wrote). Additionally, he wanted to demystify science and correct what he saw as misconceptions in the popular mind about it. In particular, he wanted to give a feel for "astronomical research, its methods and findings" by showing how astronomers actually address problems, gather data, and achieve results.

Rigutti starts his book by examining the nearest star, our Sun. He then moves to an extended description of the various kinds of stars in the Milky Way, and what means astronomers use to determine their nature, distance, type, etc. In this long second part, he covers a full range from determination of magnitude to color, temperature, velocity, and mass, as well as spectral classification. He emphasizes heavily that "cornerstone of modern astronomy: the Hertzsprung-Russell diagram." Also described are double and variable stars, clusters, novae and supernovae, pulsars, and all the types of nebulae.

The final section of the book uses these findings to explore what is known about stellar evolution and how astronomers have learned about that story. The approach is always detailed, with many charts, diagrams, and photos; it frequently relies on mathematical reasoning a bit above the college entrance level. Interspersed throughout the text are many digressions, declamations, and discussions of the fallibility of scientists, the tentative nature of their work, the gullibility of those who follow media presentations of science, and other topics that affect popular views of how astronomers work and what they discover.

I can only conclude that the book more or less achieved its purposes in Italy. It did, after all, receive two prestigious awards. Now it appears in translation in the U.S., and the author in a special foreword admits to a bit of surprise at that, declaring that, over here, "science reporting is much more professional." I concur.

In fact, I find it difficult to determine what audience his American publisher has in mind. It is surely not amateur astronomers. The author almost boasts of *never* having seen Mercury, Uranus, Neptune, or Pluto, and states bluntly that "astronomers never spend the night at the telescope just to enjoy the beauty of the starry sky." And while he declares that "this is not a textbook," by the time you are almost halfway through the book you realize Rigutti's intended audience is quite clearly composed of budding young astronomical researchers. I estimate the American audience for this book to be college sophomore astronomy majors who have an introductory course under their belts and are now ready for a more specialized topic, i.e., stellar astronomy. This is reinforced by the number of American astronomers — all connected with academia — who have endorsed the book.

But that makes for something of a puzzle because the book is grievously wordy. It could easily have been half as long. For example, the description of stellar spectra tells hardly more in 60 pages than *Burnham's Celestial Handbook* does in 15. And Rigutti's digressions gradually become almost maddening. He calls one "a brief homily," but most read more like long, boring sermons. The only compensation is the occasional barbed comment aimed at religion or in favor of radical social change — both evidence of a refreshingly European intellectual humanism, which few American professional astronomers would ever dare own up to in public.

There are some brilliant moments in this work. In fact, there is a hot 150-page essay on stellar astronomy buried here. It's unfortunate that someone didn't do a sharp editing job before bothering to translate it. Finally, and alas, it abounds in the typographical errors, awkward placement of figures, odd captions to charts, peculiar omissions, even a dropped line or two, that have become increasingly prevalent in work by American university presses. *John Mood.*

RFT-8 Newtonian Reflector

Telescopics, P.O. Box 98
La Canada, CA 91011
List price $510

The RFT-8 is a 200mm aperture, 1000mm focal length (f/5) rich-field telescope with a 32mm wide-field Plossl ocular. The scope has a modified all-wood Dobsonian mount. The metal telescope tube is held by wooden rings that allow you to rotate the tube assembly. In place of a standard rack and pinion focuser, the RFT-8 comes with a very low-profile eyepiece mount. By minimizing the distance between the final focal plane and the 1.5" diagonal, it achieves an adequate fully illuminated field with a small secondary. In this system less than 5% of the incoming light is obstructed! The mirrors are coated with 96% reflective aluminum and collimated at the factory. The result is the sharpest, crispest, highest-contrast image I have ever seen in a fast (f/4 to f/5) Newtonian reflector.

The scope is shipped in three boxes. The first contains the primary mirror in its three-point cell. You need only match up the mark on the rear of the mirror cell with the mark on the inside of the tube before screwing the cell into the telescope. The second box contains the lightweight telescope tube with the secondary flat mirror supported by its four-vane spider. Finally, the third box contains the wood mount, including the cradle that holds the telescope. Assembly goes easily, but when you mount the telescope in the cradle, take care to balance it precisely at the center of gravity. Fully assembled and ready for use, the RFT-8 weighs 40 pounds.

Since it is designed for hunting deep-sky objects at low power, the RFT-8 comes without a finder. You sight along the tube to point the scope in the general direction of the object and, using the low-power, wide-field (32x, 1½°) eyepiece, sweep to locate the object. But after a short time you find that locating the vast majority of objects requires a finder telescope. An inexpensive 6x30 will be adequate, though an 8x50 will make finding fuzzy patches of light easy.

Though the RFT-8 is light enough to be transportable, the mount is very steady. Movement is quite smooth in altitude, but sometimes a little jerky in azimuth. Still, once you become experienced in using the scope, adjustments in position of a quarter degree are easy. You simply grip the telescope cradle and apply moderate muscle power.

My first look through the RFT-8 was at a 17-day-old Moon. At 130x, tiny craterlets, rilles, ridges, escarpments, and clefts stood out conspicuously. The image was many times brighter, sharper, clearer, and more detailed than through my superfine 89mm Maksutov-Cassegrain. Star images were also surprisingly good at 130x, and hundreds of double stars of unequal brightness popped into view as I swept casually. On another night the famous Double Cluster was beautifully framed at 32x. The RFT-8 easily shows 13th magnitude stars, which are at the limit of visibility in a 6-inch.

For the price of the RFT-8, you can get larger and more powerful Dobsonians; instead of offering maximum aperture per dollar, the RFT-8 emphasizes very high quality images and an attractive physical appearance. It is also much more transportable than some of the big Dobsonians you could buy for its price. Though quite compact, I found it has enough aperture to give satisfying views of thousands of objects. (Anyone interested might want to write the company and inquire about their 6-inch version also.) *Donald Mark Weitzman*.

Visions of Other Worlds

Reuben Fleet Space Theatre
San Diego, CA

Long-ago artists drew pictographs of the Moon, stars, and supernovae on cave walls. Much later, explorers took artists with them to paint vistas of unseen and unexplored places: South America's volcanos and aurora australis, North America's Yosemite and Yellowstone. In this century, Frenchman Lucien Rudaux and American Chesley Bonestell began the space art movement by painting extraterrestrial views — and influenced a generation of young artists.

A number of space artists have recently put together a first-of-its-kind space art show, "Visions of Other Worlds," which opened at the Fleet Space Theatre in San Diego in February. It will be in Tucson until June; from there the exhibition will travel to Denver, with tentative plans for New York, Boston, Toronto, Hong Kong, and Mexico City. The show is an effort to educate the public with the awesome vistas of space, as well as to promote the coming-of-age of space art. With over 85 pieces on display, the collection is unquestionably impressive.

A number of the paintings were conceived at a workshop held in Death Valley in November and December of 1983. For example, the five-piece series on Ubehebe Crater — a volcanic pit at the north end of the monument — features a photo, three paintings of three artists' impressions of the crater's bold lava flows, and a fifth by Michael Carroll transforming Ubehebe into a caldera on Io. Then there is Kim Poor's "Red Shifting," with dust-strewn sand dunes and pearl-like clouds in the sky of Mars. Joel Hagen's "Martian Sunrise," an elegant play of light and color, combines Polynesian water navigational systems with wind-sculpted dune patterns. Don Davis's "Mars Hill," with its light gold/yellow/brown strewn rocks, is a landscape perhaps just out of the view of Viking's camera.

Like all good science fiction writers, space artists know they must be scientifically accurate, but in the end the art itself — the visual and sensual effects — is the most important. To illustrate this, in William Hartmann's "Surface of Mercury," the viewer crouches just behind an outsized promontory on the edge of a mercurian impact crater. The Sun is just kissing the boulder, displaying the corona and zodiacal light, while white Venus and blue Earth float in the background. Like any novelist or playwright who combines action and emotion to create excitement, Hartmann convenes the astronomical elements to please and involve the viewer. Moreover, this scene is entirely possible, given the knowledge we have of colors, textures, landforms, and so on. Hartmann, a professional planetary scientist, has created a playful and arresting picture.

Astronomy ultimately involves the imagination in unthought-of ways. When Earthlings witness a total lunar eclipse, the Moon experiences a total solar eclipse. It is the realm of the artist to carry us to where we can see such things from different perspectives — and this free ride into space is what "Visions of Other Worlds" is all about. Don Dixon's "Saturn from Iapetus" shows Saturn passing in front of the Sun and creating a diamond ring effect, and it's stunning. Jupiter's swirling reds and ochers dominate the sky of ice-blue Ganymede as seen by artist Rick Sternbach. Davis's "Venus Volcanos" puts the viewer just above seas of fire and lightning. And amidst the delightful wonder, there is also Jon Lomberg's somber series of four views of Earth: bright sparkles mark where missile strikes have obliterated cities and an intense black cloud of radioactive dust spreads inexorably over the delicate blues of our planet.

For the space-hardware buffs, the show features "Tumbling Astronauts" in state-of-the-art spacesuits by Maralyn Vicary-Diddams and Pamela Lee's "Earth Solar Panels." There's also Lomberg's highly detailed space colony "Astr" and James Hervat's famous "Galileo Probe," a painting in which he included NASA's last-minute design alterations. Larry Ortiz contributes "Survey Team," a group dressed in streamlined Apollo-era suits on an atmosphereless surface. Overhead shine stars and nebulae in a patterned configuration of lights and colors, brilliant beacons in the vast sky.

These space artists seem determined to take up any slack in the country's space program. Robert Kline's painting, "Destiny," puts sand dune explorers under a sky filled with the familiar face of Albert Einstein, smiling like a whimsical planet. If mankind ever "lights out for the territories" of the stars, we can be sure some of those travelers will be packing canvases, brushes, and pigments. *Stephanie Mood*.

Essentials of the Dynamic Universe

Theodore P. Snow
486 pages, softcover, no price given
West Publishing (1984)

Essentials of the Dynamic Universe is an introductory college text that covers historical material on Tycho, Kepler, Copernicus, Newton, and Galileo, as well as information on light and telescopes, stars, planets, galaxies, and cosmology.

Man and the Planets

Duncan Lunan
306 pages, hardcover, $17.95
Ashgrove Press (1984)

Subtitled "The Resources of the Solar System," this work investigates man's potential in visiting and making use of moons and planets in the solar system.

Imaging Saturn: The Voyager Flights to Saturn

Henry S.F. Cooper, Jr.
210 pages, hardcover, $19.95
Holt, Rinehart and Winston (1983)

Henry S.F. Cooper, Jr. writes for *The New Yorker*; his coverage of space missions has been highly lauded. We now have his reportage of the Voyager 1 and Voyager 2 flybys of Saturn and the scientists who planned those encounters in book form. Cooper gives us an inside view of people, images, and science which he observed while in the imaging team area with the scientists as new pictures and data arrived. The narrative's style is engaging with personalities clearly drawn. *Imaging Saturn* is must reading for space-mission-ophiles. *Richard Berry.*

Yale Catalogue of Bright Stars
Eight 8-inch CP/M format, SSSD floppy diskettes, $40
Public Domain Software, P.O. Box 640, Stanley, NC 28164

The Yale Observatory *Catalogue of Bright Stars* contains positional, brightness, color, and spectral type information on about 9200 stars brighter than 6.5 magnitude. It is now available in machine-readable form from Public Domain Software, a non-profit distribution house. The floppies come with information on the YBS catalog and its history and organization. The price includes shipping charges for continental North America (and Hawaii); contact them for rates elsewhere.

Atlas of the Solar System
David A. Hardy
96 pages, hardcover, $26.50
World's Work (1983)
(Order from: David and Charles, Inc., North Pomfret, VT 05053)

According to the author, this book "is intended not only as a timely retrospective of man's past discoveries and achievements in exploring the solar system, but as a look ahead at the vast potential scope . . . for his evolution in the future." Hardy, a well-known British writer/illustrator, has put together an entertaining and informative book for young adults. It contains sections on astronomical history and possible routes for the future exploration of our planetary system. Hardy includes over 60 imaginative and enthusiastic diagrams and paintings. *Atlas of the Solar System* is a pleasant compilation of current knowledge on the Sun and planets.

Maxwell on Saturn's Rings
Stephen G. Brush, C.W.F. Everitt, and Elizabeth Garber, eds.
199 pages, hardcover, $25
MIT Press (1983)

Maxwell on Saturn's Rings is an historical compilation of notes, scratch-pad calculations, and letters by James Clerk Maxwell, centering on his 1856 essay "On the Stability of the Motion of Saturn's Rings," which established him as a great mathematical physicist. The core of the book is Maxwell's prize-winning essay itself.

Starwatch
Ben Mayer
144 pages, softcover, $7.95
Putnam (1984)

Starwatch is an observing manual for locating constellations and notable stars and deep-sky objects within them. It promotes a simple method of tracing "starframes" from the book, which can be held up to the sky for easy identification of various areas of interest. The bulk of the book provides full-page negative and positive star maps; information on the "Problicom" nova-discovery program, telescopes, seeing conditions, eclipses, and sunrise and sunset is also included.

Space History
Tony Osman
216 pages, hardcover, $16.95
St. Martin's Press (1983)

A brief literary account of man's conquest of space comprises this work, written by an English journalist. Included with the text are many black and white and several color images of early rocket attempts, the Mercury and Apollo programs, the Space Shuttles, and future possible space colonies. The book contains a short glossary of space terms and a bibliography suggesting further reading.

Chesley Bonestell's Vision of Space
Art by Chesley Bonestell
40 slides and cassette tape, no price given
Garc Corporation (1983)

This slide set, accompanied by a narration cassette, provides 40 examples of Chesley Bonestell's classic astronomical art made during the 1940s and 1950s. The emphasis is on lunar landscapes and spacecraft of various types (much of it startlingly on target!), and hypothetical scenes of Mars, Venus, Mercury, Saturn, and Jupiter also appear.

Worlds Beyond: The Art of Chesley Bonestell
Ron Miller and Frederick C. Durant III
133 pages, softcover, $14.95
The Donning Company (1983)

This volume contains reproductions of many of Chesley Bonestell's astro-paintings, information about the man himself, and a running commentary from various science fiction authors and artists. The book also presents examples of Bonestell's other work, most notably for a number of motion pictures such as *Citizen Kane*, *The Hunchback of Notre Dame*, and *The Adventures of Mark Twain*.

"One of nature's most awe-inspiring spectacles"

And now you can see it for yourself. Eclipse Chasers, their families and friends are invitied to take part in *Eclipse '84 Expedition to the South Pacific.*

For 15 exciting days, from 11-25 Nov. 1984 you can be part of an exciting cultural/scientific expedition, where you'll visit New Zealand, often called "God's own country" due to its majestic beauty; New Caledonia, that perfect blend of Parisian style and Melanisian langor; and Tahiti long famous as an idyllic retreat.

You'll stay in deluxe hotels, enjoy fine continental and local cuisine, experience native performances, sightsee extensively, and even relax on magnificent beaches. But of course, this is more than just a vacation. Renowned guest lecturers will present astronomical and eclipse fact, fiction and lore. And of course there is the *piece de resistance* an overnight cruise to the ideal viewing site on the center-line of the path-of-totality.

There's much, much more as well. Cocktail parties, astrophotography clinics, etc. This is the trip of a lifetime. (To know how fantastic a trip this is, just ask anyone who has taken part in any of our last four successful Eclipse Expeditions.) So consider taking part. It's an experience you'll treasure for a lifetime. Send for the complete brochure and details now.

International Seminar Programs
Suite 100 • 645 East Park Avenue
Long Beach, N.Y. 11561

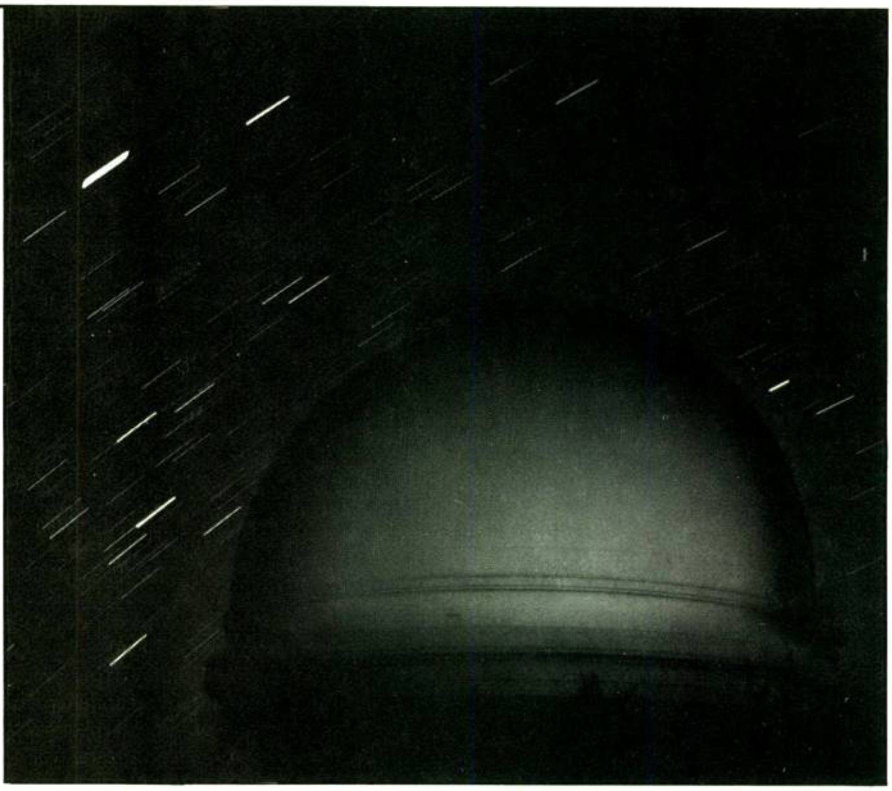
NAME

STREET

CITY STATE ZIP

Moon Diminishes Perseids

by
Fred Schaaf



On Palomar Mountain, California, Kevin Parker photographed the dome of the 5-meter Hale telescope — the world's second largest — illuminated by starlight. The exposure, made with a 5mm f/1.8 lens and 125-speed film, lasted 10 minutes. The bright streak to the upper left of the dome is Sirius.

The Wanderers

None of the planets except Mars is moving rapidly this month. The Red Planet, though fading, is still bright enough to put on quite a show as it slides day by day from Libra across Scorpius to the border of Ophiuchus. Viewers in the Americas this month will be fortunate enough to see the Moon appear near a number of the planets in the convenient evening hours. And in early August all eight of our fellow planets are visible at once in the *evening* sky.

The Moon lies just south of Saturn at 0h UT on the 4th — in fact, observers in southern South America will witness an occultation of the planet. The people who see Saturn occulted can, with a telescope, see Uranus occulted on the evening of the 5th. On the evening of the 7th, the Moon lies just south of brilliant Jupiter, making a grand sight. Then for the next few weeks the Moon cruises through the planetless morning sky until it passes invisible Mercury at New Moon and comes moderately close to Venus on the evening of the 27th.

The same Moon that looks attractive beside the evening planets is a spoiler for the **Perseids** — normally the year's most-observed meteor shower. The Perseid maximum on the 12th and 13th occurs at the worst possible time, just a few days after Full Moon. The Perseids are so bright and numerous that these nights are still promising if you observe away from city lights. Meteor watchers may also count several dozen Capricornid and Delta Aquarid meteors per hour from the south after Moonset on the first few days of the month.

The best show, however, is provided by **Mars**. The ruddy planet, still shining at magnitude 0, starts August near faint Iota (ι) Librae. Watch it approach the vertical line of bright stars that forms the head of Scorpius — where will it pass through?

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

The answer comes on the night of August 21-22 in America, when Mars passes only 23 arc-minutes south of Delta (δ) Aquarii, a 2.5 magnitude object. At month's end, Mars is near eastern quadrature (90° east of the Sun — thus due south and highest around sunset). It is also then very near the globular cluster M-80 and just three days away from conjunction with the "rival of Mars," Antares.

The inner planets have a conjunction on the 16th; it is, however, a poor one, since **Venus** is farthest north of the ecliptic on the 6th and **Mercury** is at greatest latitude south of the ecliptic (over 7°) on the 26th. Mercury is over 6° south of Venus at their conjunction, and though their elongation is 18°, their altitude is much worse. Mercury falls back to inferior conjunction on the 28th, after which it will rise into the morning sky for a fine September apparition (for the northern hemisphere).

Venus is still not very prominent due to its low altitude, which is a shame since it passes only 1°4' north of Regulus on the 7th. Near month's end Venus is actually near a minimum in brightness (still at about magnitude −3.9 though).

In addition to Mars, the other outer planets are all well placed for observation — and, interestingly, all are nearly motionless this month. This year, the planets beyond Mars are positioned so that all of them halt their retrograde motion within 1½ months of each other. **Saturn** and Pluto halted last month. Uranus is stationary on August 18th, Jupiter on August 29th, and Neptune on September 9. Jupiter is about magnitude −2.0, and Saturn about 0.8 as the month ends; they are still north of the Teapot of Sagittarius and northwest of Alpha (α) Librae, respectively.

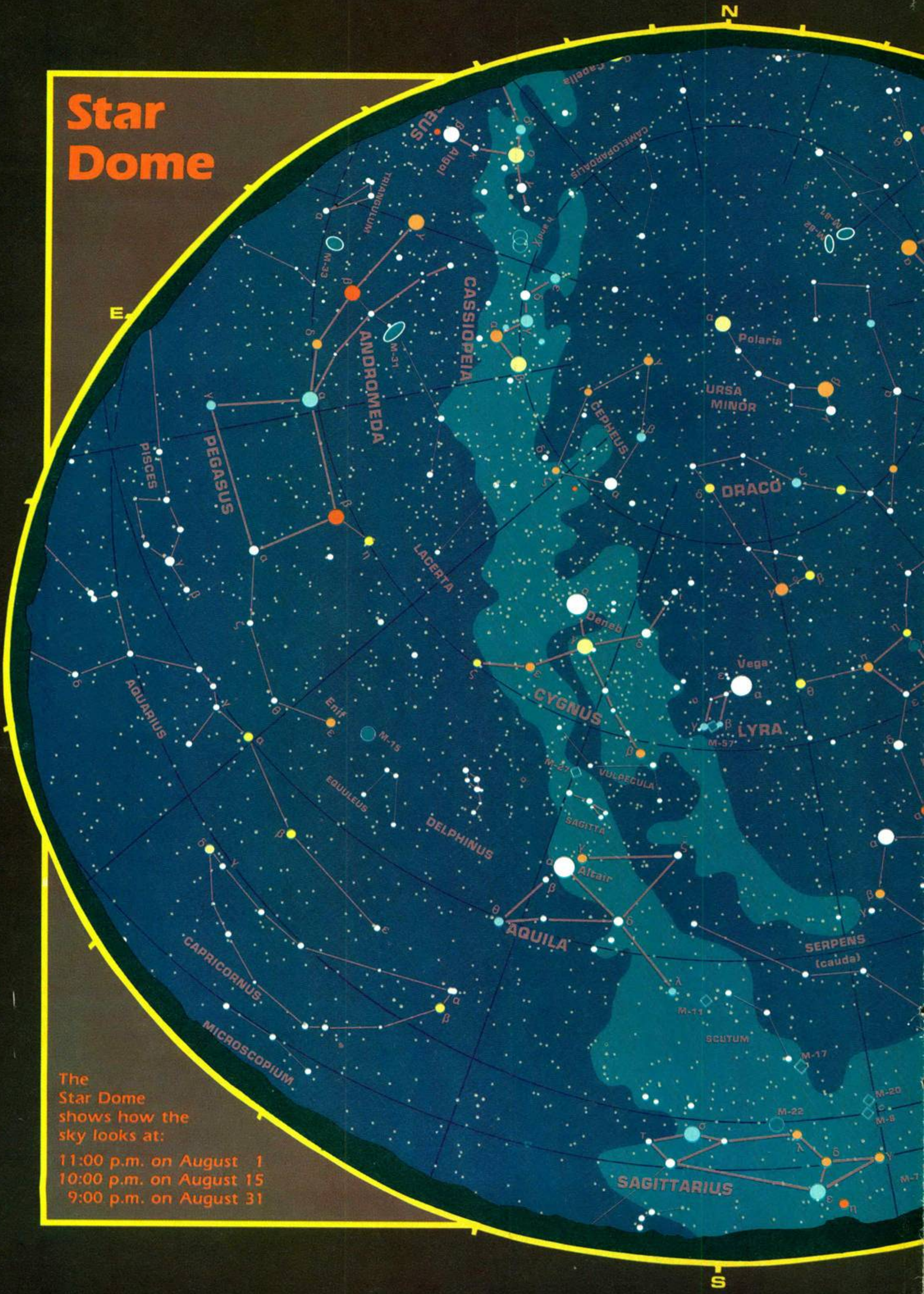
In October 1980, Fred Espenak photographed planets Venus, Jupiter, and Saturn rising above the McMath solar telescope on Kitt Peak, Arizona. He used a 50mm f/2 lens, 400 ASA emulsion, and a 30-second exposure. The telescope's slanted section continues into the rock, where astronomers study the solar image.

The Starry Sky

This is the best month to observe the **Sagittarius** Milky Way, the region toward the center of the Galaxy. Many observers know there are telescopic wonders here; in our time of increasing light pollution, however, few realize that many clusters and nebulae can be spotted with the naked eye or binoculars. And the panorama of the entire constellation, enveloped in misty cascades of the Milky Way clouds, is a view best seen by the naked eye — in dark skies, of course.

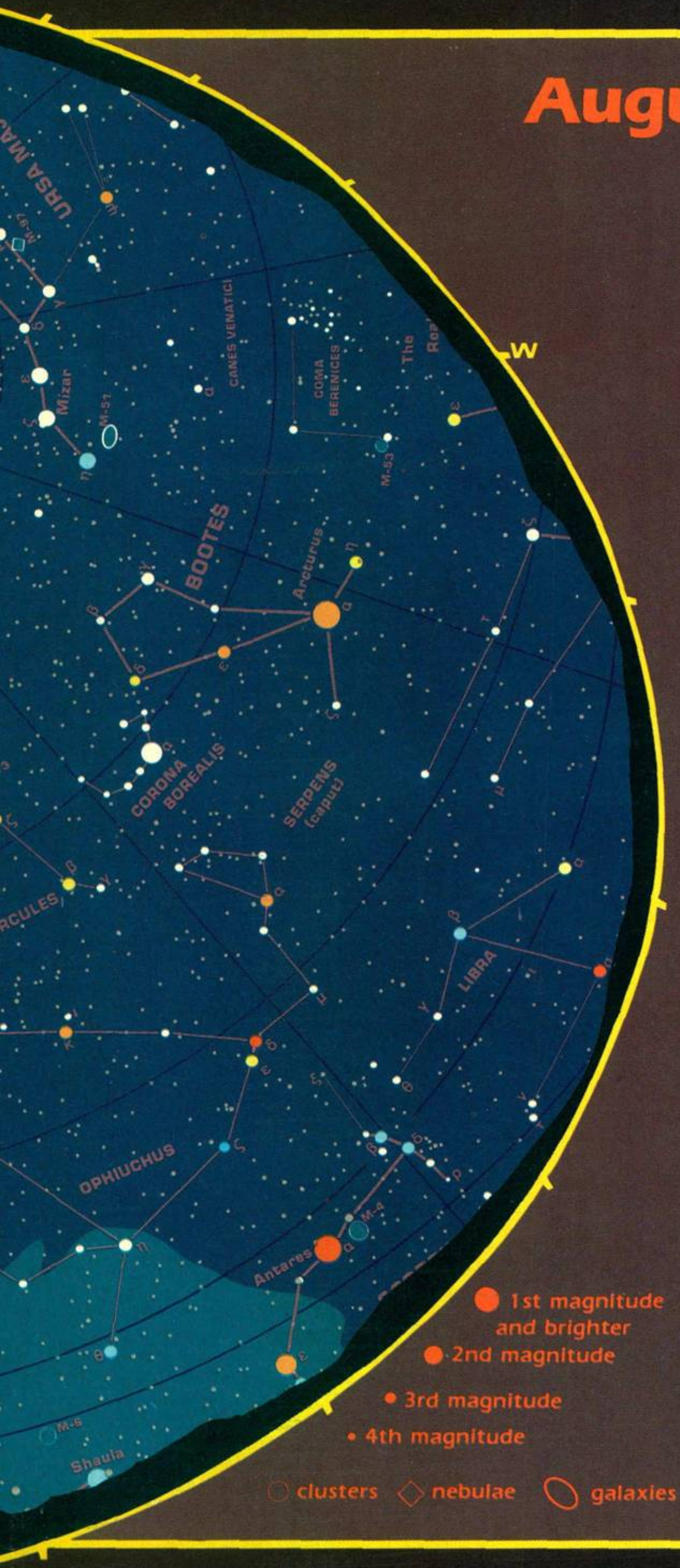
Although the Summer Triangle of **Vega**,

Star Dome


N
E
S
EUS
Algol
Capella
CAMELOPARDALIS
TRIANGULUM
M-33
CASSIOPEIA
ANDROMEDA
M-31
h and χ
M-81
M-82
Polaris
URSA MINOR
CEPHEUS
DRACO
PISCES
PEGASUS
LACERTA
Deneb
CYGNUS
Vega
LYRA
M-57
Enif
M-15
AQUARIUS
EQUULEUS
DELPHINUS
M-27
VULPECULA
SAGITTA
Altair
AQUILA
SERPENS
(cauda)
CAPRICORNUS
MICROSCOPIUM
M-11
SCUTUM
M-17
M-20
M-8
M-22
M-7
SAGITTARIUS

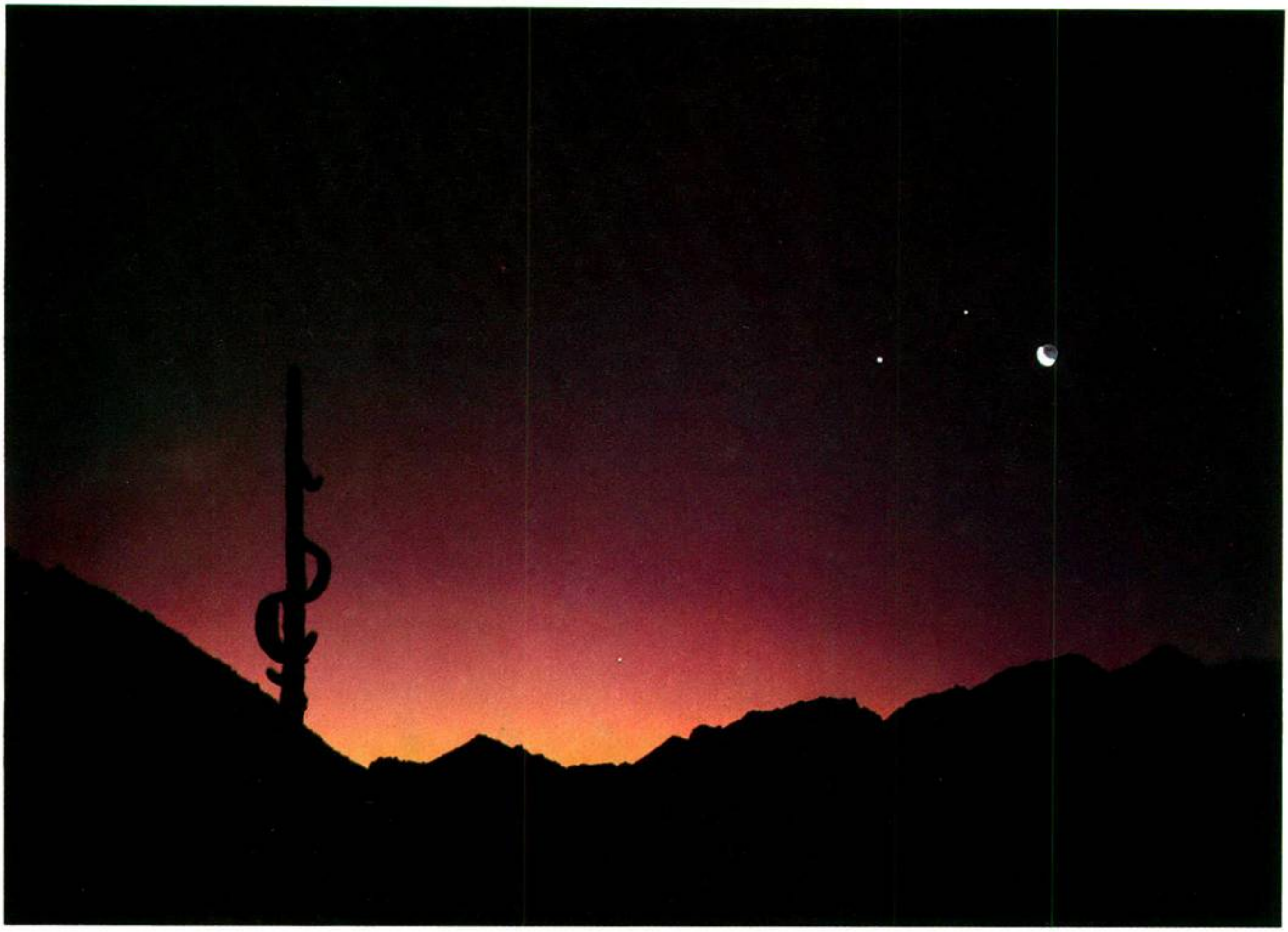
The Star Dome shows how the sky looks at:

11:00 p.m. on August 1
10:00 p.m. on August 15
9:00 p.m. on August 31


URSA MA
M-97
Mizar
M-51
CANES VENATICI
COMA BERENICES
M-53
The Rea
W
BOOTES
Arcturus
CORONA BOREALIS
SERPENS (caput)
RCULES
LIBRA
OPHIUCHUS
M-4
Antares
M-6
Shaula
1st magnitude and brighter
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

August Sky Almanac

1st	Mercury is at greatest eastern elongation in the evening sky — though this is an unfavorable apparition.
3rd	First Quarter Moon occurs at 10:33 p.m. EDT. Around the same time, the Moon will pass near Saturn.
4th	The Moon will pass to the north of Mars tonight.
7th	This evening, Venus lies about a degree north of Regulus in Leo. Later tonight, the Moon will pass 2° south of Jupiter.
11th	Full Moon is at 11:43 a.m. EDT.
12th	The predawn hours today mark the peak of the annual Perseid meteor shower. But as the Moon is Full less than a day before, all the fainter Perseids and many of the medium-brightness ones will be obscured.
15th	The Moon passes through apogee at 12:51 a.m. EDT: 252,139 miles.
16th	Mercury lies 6° south of Venus this evening.
19th	Last Quarter Moon occurs at 3:40 p.m. EDT.
21st	Mars has a close conjunction with the star Delta Aquarii.
26th	New Moon happens at 3:25 p.m. EDT.
27th	The Moon is at perigee at 12:54 p.m. EDT: 222,726 miles. Also, it will lie near Venus this evening.
28th	Mercury is at inferior conjunction; it moves into the morning sky, heading for greatest western elongation on September 13th.
31st	The Moon and Saturn will be close together tonight.



In late January Frank Zullo loaded his 35mm camera body with 64 ASA film, mounted it on a tripod, focused his 50mm f/1.8 lens at infinity, and set out to photograph the planets. He made this 12-second exposure of the Moon (seen here overexposed), Jupiter, and Venus together with a lone cactus.

Deneb and **Altair** is prominent high in the sky, it will be at its all-around best next month. Therefore, let us concentrate on the Milky Way and its attendant constellations south of **Aquila** the Eagle.

Just south of the celestial equator lies a small, intense bright patch of Milky Way — the **Scutum Starcloud**, named after the dim constellation it renders relatively inconspicuous.

The Scutum Starcloud is less likely to be blocked by trees or dimmed by haze, than the **Sagittarius Starcloud**, about 15° to its southwest. Yet another factor that makes the Scutum cloud stand out is its proximity to the widest part of the tongue of dark dust called the "Great Rift." The constellation **Serpens Cauda** (the Serpent's Tail) fits up into the Rift perfectly.

At a dark site you can carefully observe a bright spot of condensed light within the Scutum Starcloud. This is **M-11**, also called the Wild Duck Cluster, one of the finest of all open star clusters. The best views come with binoculars and low-power telescopes.

Even against the glowing wash of bright Milky Way, other Messier objects stand out distinctly to the naked eye below Scutum in the realm of Sagittarius. On a dark country night, you can, without using reference stars, glimpse one after another of these objects. One of them is **M-24**, which is really just a 2° by 1° patch of especially dense Milky Way. To me it seems beyond question the brightest of all knots of luminosity in the Milky Way. It is sometimes called the Small Sagittarius Starcloud.

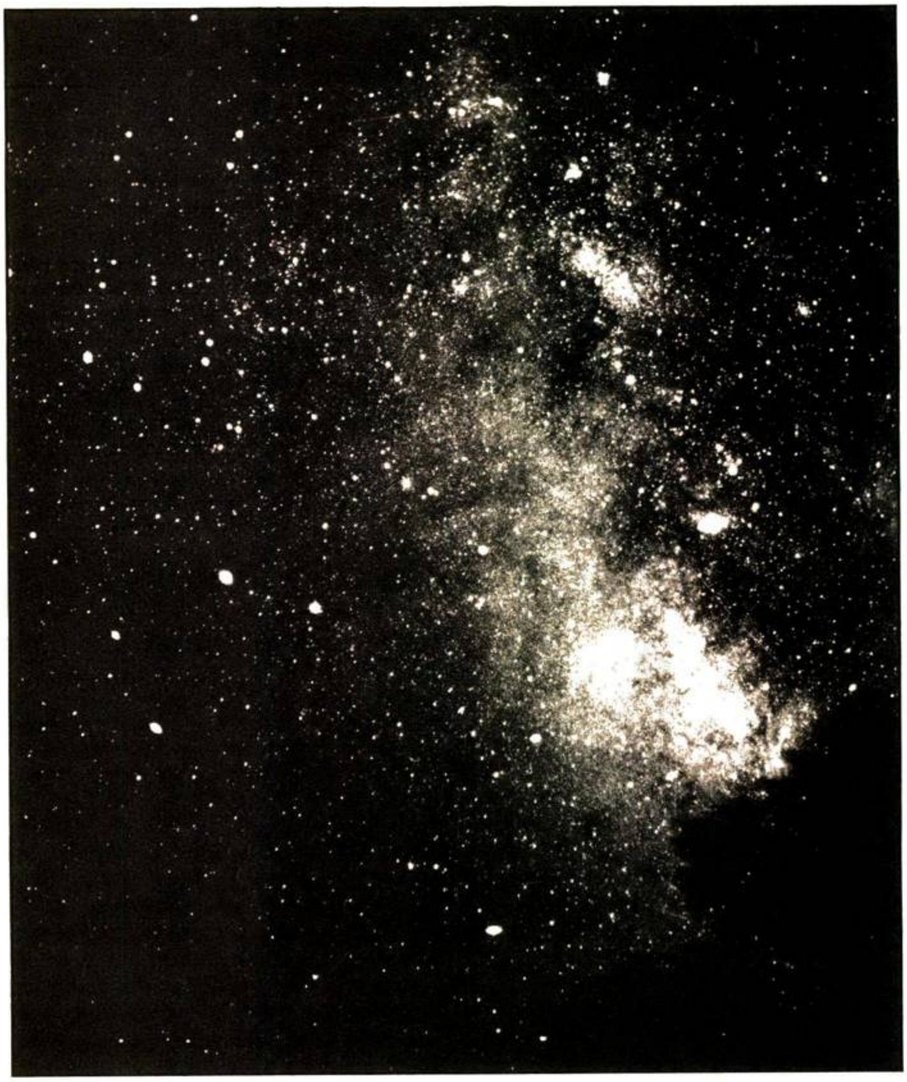
Scanning a bit farther to the southwest, your naked eye hits upon a somewhat smaller and less brilliant glow, nevertheless sizable and quite prominent in good skies. This time we are not seeing just the combined light of many distant stars; we are also seeing the luminosity of a cloud of gas — a nebula, the summer's biggest and brightest. The object is **M-8**, the Lagoon Nebula. If we use binoculars, we can detect a number of clusters and other nebulae near both M-24 and M-8.

And there are quite a few more objects to behold here. One could hardly miss the biggest and overall brightest starcloud, the Large Sagittarius Starcloud. Fittingly, in the direction of this cloud — though far behind it — is hidden the magnificence of the Milky Way's center. And not far to the south and west of the Large Sagittarius Starcloud, the naked eye can easily behold two huge clusters by the Scorpion's tail, **M-6** and **M-7**.

How many globular clusters have you seen with your naked eye? If you live in the tropics or southern hemisphere, you have probably enjoyed such a view of the clusters **Omega** (ω) **Centauri** and **47 Tucanae**. If you are a more northerly observer with really dark skies, you may have glimpsed sixth-magnitude **M-13** in Hercules. A small number of globular clusters are just within naked-eye range; the one nearest in brightness to M-13 is worth attempting even if it is rather low for U.S. observers. It is **M-22**, just a few degrees east of the star Lambda (λ) Sagittarii, the point at the top of the Teapot figure of Sagittarius. Some telescopic observers find M-22 more beautiful than M-13, despite its lower altitude.

The individual naked-eye stars of Sagittarius may be overwhelmed by the Milky Way in a dark sky, but they should not be ignored. Two bright second-magnitude stars, **Kaus Australis** and **Nunki**, mark the southwest and northeast corners of the Teapot figure. The brighter stars here can also be shaped into a less convincing if equally artistic Archer.

This year, Jupiter is migrating back and forth over the top of the Teapot and in front of the dense, wide section of Milky Way. It is a magnificent crown jewel (and, by the way, the rough circlet of **Corona Australis**, the Southern Crown, is located south of Sagittarius). You should remember, however, that in Sagittarius there are literally dozens of splendid sights for observers — with naked eye, binoculars, or telescope.



Steven Simmerman's 5-minute guided exposure captures highlights of the summer Milky Way in Sagittarius. The Lagoon and Trifid Nebulae, the Large and Small Starclouds, and various other nebulae and clusters are visible. He used a 50mm f/2.0 lens and 103a-E emulsion.

Skylore

Last month we pursued the story of Gilgamesh, the legendary Sumerian king who may be the original figure represented by the constellation Hercules. We saw how Gilgamesh and his best friend Enkidu overcame the giant creature Humbaba and how Ishtar placed a curse on Enkidu so that he died, leaving Gilgamesh bereaved and stricken with the thought of his own mortality.

Gilgamesh knew that the immortal couple — Ut-napishtim and his wife — were said to live in the farthest west. He set off on the longest journey he had ever undertaken. After countless hardships, the proud king came to Mount Mashu, the western home of the Sun god. His eyes were at first blinded by the radiance, but after a few moments he was able to make out the most awesome figures he had ever seen — the towering forms of gigantic scorpion-men who guarded the mountain. Going onward at that point was perhaps the bravest thing that Gilgamesh ever did. But he did go onward and bowed low before one of the scorpion-men. The huge guardian pointed to a gate that opened in the mountainside. Gilgamesh entered the passageway and began to follow the dark tunnel, which led to the heart of the mountain.

Gilgamesh found the boatman Urshanabi, who was willing to lend Gilgamesh his boat but warned him that no mortal could succeed in reaching the land of Ut-napishtim this way. The rocks and swirling waters around that land were treacherous, and one touch of the waters was instant death. Gilgamesh still would not give up and asked the boatman's advice. Urshanabi said his only hope would be to cut 120 long poles from giant trees of the forest and use these to stave off the disaster of the rocks. Again Gilgamesh rose to the challenge, felled the trees, cut the poles, and set off in the ship. Each time he used a pole he would discard it, so that the power of the deadly waters would not be transmitted to him. His supply of poles was only just enough — but he arrived. He had come to the shore of the immortal Ut-napishtim and his wife.

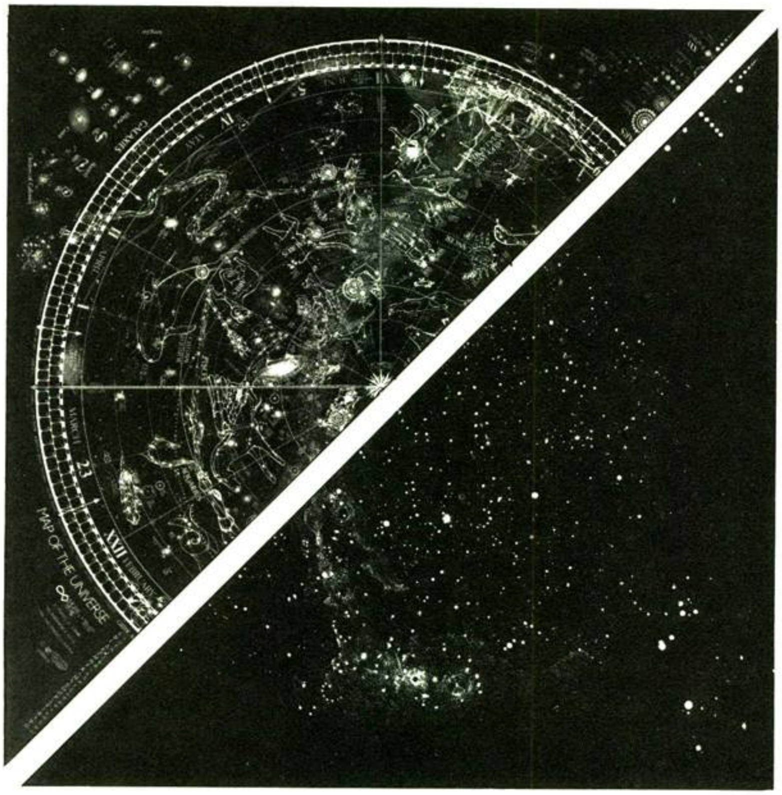
Before long he was standing before the couple in their throne-room and told them of his quest. Ut-napishtim was skeptical. "Are you worthy of immortality? Can you stay awake for the next six days and seven nights, as I once did?" Gilgamesh swore that he could — but after his great efforts he was the weariest he had ever been, and now a still greater weariness had fallen upon him. Before long, his eyes closed and his head nodded. When he awoke with a start, the man and woman were still there and the man declared, "If you have not the patience and fortitude to conquer sleep for a week, how can you expect to conquer the greater sleep called death forever?"

But just when Gilgamesh thought he was defeated, Ut-napishtim's wife pleaded his case and Ut-napishtim had mercy on him. Gilgamesh could obtain immortality for himself and his people if he could achieve one final feat. Gilgamesh dove into the sea (apparently a part where the water's touch was not fatal), a place almost as deep and cold as death itself. Somehow he kept his wits and saw in the cave at the bottom, as they told him, a beautiful plant — the flower of youth! It pricked his fingers as he grabbed it, but he managed to hold his breath still longer and streak up towards the surface. He exploded into the sunlight and air and still he had it — the flower of youth.

One day on the road home, Gilgamesh came upon what seemed a pleasant pool of water in a desert land. He set the flower down and went for a swim. As he returned he saw the flower of immortality being carried off — in the mouth of a snake, which had been attracted by its fragrance. When he got to shore the snake was gone, and search as he might, he could not find a trace of it.

When he returned home his people welcomed him, but their king would not be comforted. "Yes, it is I who have returned," he said, and he recounted his labors. What were they all for? "For this — to have brought eternal life not to my beloved people, but to the race of serpents!"

If the stars of Hercules originally represented Gilgamesh, then perhaps Draco is the monster Humbaba he defeated; Sagittarius may be his half-beast friend Enkidu; Aquila, the eagle of Gilgamesh called Alallu; Taurus, the Celestial Bull Gudanna he vanquished; and Scorpius, one of the towering scorpion-men he faced. If any of these guesses are true, they are remarkable fragments of legend that somehow did not quite dissolve into the ever-recombining sea of man's ceaseless imagination.



EXPLORE THE NIGHT SKY WITH THE

glow-in-the-dark

MAP OF THE UNIVERSE

The **MAP OF THE UNIVERSE** helps you identify stars, constellations, supernovas, black holes and other celestial objects. This unique tool includes all the constellations visible from our Northern Hemisphere in full color on a 36" x 36" black background. And most of its stars are coated with a phosphorescent ink designed to glow in the dark.

Each Map is accompanied by a 16-page booklet giving instructions for viewing, as well as some of the legends about the constellations.

Learn the night sky indoors — so you can better search the heavens outdoors.

$10.95 includes postage and handling

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Corp., Order Dept., P.O. Box 92788, Milwaukee, WI 53202

WHEN YOU TURN TO THE SKIES — TURN TO YOUR ASTRONOMICAL FRIEND: ROGER W. TUTHILL

TRUST

— What a Word!!!

We firmly believe that the mail order business must be based on this word. That is why we ship your order immediately and do not wait for your check to clear!! Since you are willing to trust us, we think we should be willing to trust you and WE DO!!

Do not be afraid to order from us. We guarantee FULL satisfaction or your money back. You have my word on it.

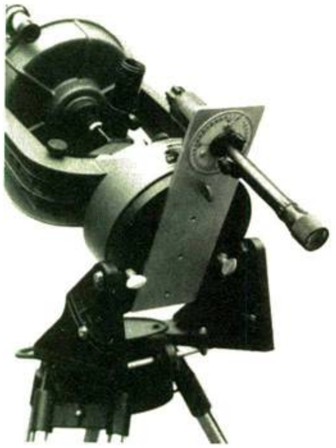
Roger W Tuthill

CALL TOLL-FREE:

1-800-223-1063

FOR INFO ON TUTHILL CUSTOM-ENGINEERED ACCESSORIES FOR CELESTRON TELESCOPES:

- Huge 50mm & 80mm Diameter Right-Angle Finders
- Rock-Steady Isostatic Equatorial Mount
- Unique Stereoocular Viewer for 1¼" eyepieces
- Accurate Space-Age Celestial Navigator Digital Displays
- Heated NO DU Caps for less frustration from dewing.
- Easy to Install Manual R.A. Slow Motion Micro Drive



PRECISION POLAR AXIS FINDER

(USA Patent #4,260,253.) Get perfect celestial polar alignment quickly and easily every time without leveling your tripod. When the centered 4x crosshairs are set on Polaris the built-in 0.8 degree offset barrel points directly and precisely to the pole. Novel Polaris date and time chart supplied FREE. Now available with FREE Ring-o-Fire glowing crosshairs for easy viewing. Also available for most other scopes.

Send a large (9" x 12" — 3 oz.) BROWN Self-Addressed Stamped Envelope for our Complete Information Kit including "Tuthill's Twenty-Two Telescope Tips."

Interested in a Schmidt Cass scope? We urge you to get a CELESTRON® **EVEN** if you don't get it from us. You will be a lot happier with the optical perfection and proven performance.

WE REPAIR ***CELESTRON*** SCOPES

MasterCharge, VISA *Trademark

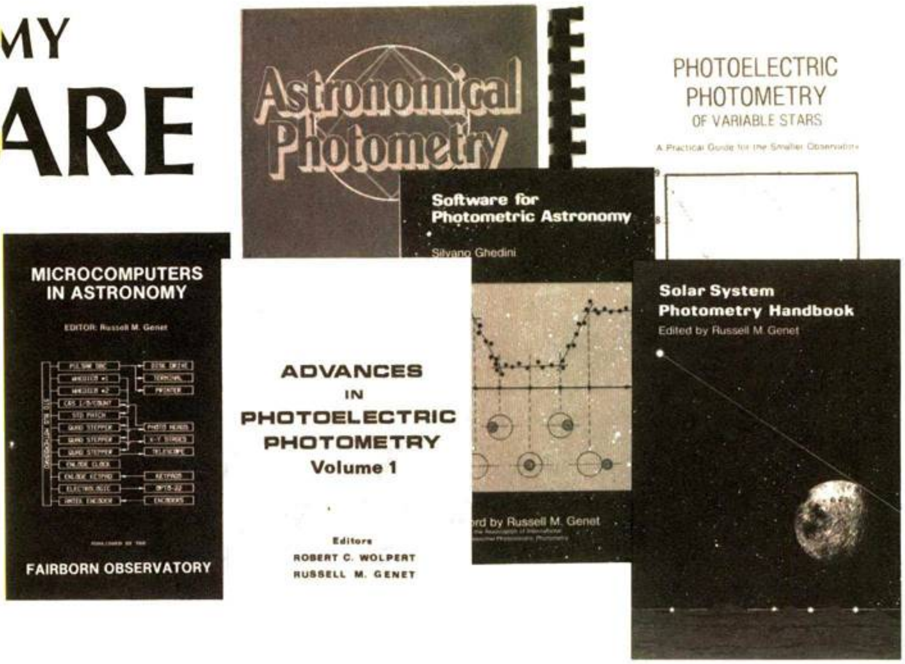
ROGER W. TUTHILL, INC.

Telephone: (201) 232-1786

11 Tanglewood Lane, Dept. A, Mountainside, N.J. 07092

ASTRONOMY
SOFTWARE

— ADVERTISEMENT —


Astronomical Photometry
PHOTOELECTRIC PHOTOMETRY OF VARIABLE STARS
A Practical Guide for the Smaller Observatory
Software for Photometric Astronomy
Silvano Ghedini
MICROCOMPUTERS IN ASTRONOMY
EDITOR: Russell M. Genet
FAIRBORN OBSERVATORY
ADVANCES IN PHOTOELECTRIC PHOTOMETRY Volume 1
Editors
ROBERT C. WOLPERT
RUSSELL M. GENET
Solar System Photometry Handbook
Edited by Russell M. Genet

Astronomical Photometry, by Arne A. Henden and Ronald H. Kaitchuck. Written at a college text level, covers the theoretical side of photometry. In addition to covering atmospheric extinction corrections, the UBV system, absolute calibration, and constructing photometers, it details the types of variable stars and why astronomers observe them. 392 pages, hardcover, **$30.95.**

Photoelectric Photometry of Variable Stars, by Douglas S. Hall and Russell M. Genet. A wealth of practical hands-on advice for photoelectric photometery — from using a photometer to data reduction. Descriptions of amateur observatories and addresses of suppliers and amateur organizations included. 281 pages, paperback, **$18.50.**

Microcomputers in Astronomy, ed. by Russell M. Genet. Thirty papers presented at the Fourth Fairborn Symposium detail the present state-of-the-art in applying microcomputers to automatic telescope control. An absolute must for everyone interested in controlling telescopes or photoelectric photometers by computer. 253 pages, paperback, **$23.95.**

Advances in Photoelectric Photometry, Vol. 1, ed. by Russell M. Genet and Robert C. Wolpert. Nineteen papers on the latest achievements in photometry including tips on how to do photometry from poor sites, building fully automated telescopes and descriptions of typical productive amateur-run observatories. A must for the up-to-date amateur. 240 pages, paperback, **$23.95.**

NEW!

Software for Photometric Astronomy, by Silvano Ghedini. You don't have to write your own software — Ghedini has already done it. Written in HP BASIC, the programs begin with air mass and extinction corrections, then leap to determining time of minimum light and period analysis of variables. 221 pages, paperback, **$27.50.**

Solar System Photometry Handbook, ed. by Russell M. Genet. Continuing in the tradition of the popular *Photoelectric Photometry of Variable Stars,* this book tells how to time asteroid occultations and how to look for unseen companion stars during lunar occultations. Read how to make photometric studies of sunspots, or planets, or comets. Covering both ordinary and high-speed photometry as well as theory, equipment-building, and technique, this book belongs in the library of every amateur photometric observer. Over 200 pages, paperback, with diagrams, photos, and index, **$18.50.**

NEW!

To order, use the AstroMedia order form bound into this magazine or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Foreign orders, add $2.50.

Celestial BASIC, by Eric Burgess. Written for Apple II computers, but modifiable to run on other machines. Includes programs for precessing star coordinates, phases of the Moon on any date, and far more. Makes use of the Apple's graphics capability. 300 pages, paperback, **$17.50.**

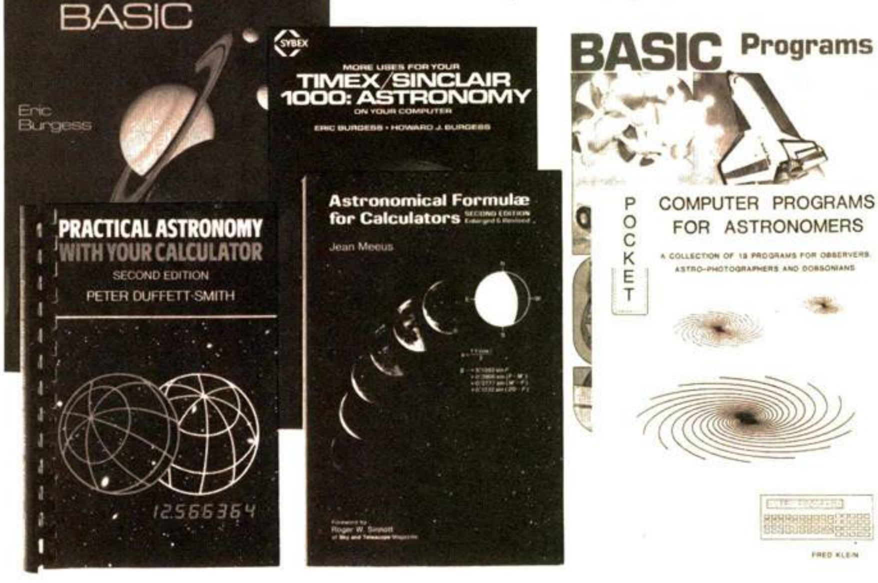
More Uses for Your Timex/Sinclair 1000: Astronomy on Your Computer, by Eric and Howard J. Burgess. Contains ready-to-run programs for calculating the right ascension and declination of the Sun, the Moon, and all the planets for any date, the positions of Jupiter's Galilean satellites, elongations and phases for Mercury and Venus, and much more! 153 pages, paperback, **$9.50.**

BASIC Programs for Scientists and Engineers, by Alan R. Miller. A cookbook of mathematical routines. Includes matrix multiplication and division, solving equations, how to find a best-fit curve, sorting, numerical integration, and how to evaluate your BASIC interpreter. 318 pages, paperback, **$17.50.**

Practical Astronomy With Your Calculator, 2nd edition, by Peter Duffett-Smith. Tells you how to use a scientific calculator to convert local standard time to sidereal time, find the time of moonrise and set — and more. Assumes no specialized knowledge, provides complete examples. 188 pages, paperback. **$11.50.**

Astronomical Formulae for Calculators, 2nd edition, by Jean Meeus. For the more mathematically advanced, provides formulae for you to write programs to determine the positions of the jovian moons, the principal perturbations affecting the planets — and lots more. Fully worked-out examples. 201 pages, paperback, **$15.50.**

Pocket Computer Programs For Astronomers, by Fred Klein. Contains 13 Pocket Computer BASIC programs for calculating altitudes and azimuths, jovian satellite positions, age and phases of the Moon, comet positions, and much more. Besides the programs, it also tells you how the programs work so you can customize them for machines other than the Pocket Computer. 100 pages, paperback, **$12.95.**


Celestial BASIC
Eric Burgess
SYBEX
MORE USES FOR YOUR TIMEX/SINCLAIR 1000: ASTRONOMY ON YOUR COMPUTER
ERIC BURGESS • HOWARD J. BURGESS
BASIC Programs
PRACTICAL ASTRONOMY WITH YOUR CALCULATOR
SECOND EDITION
PETER DUFFETT-SMITH
Astronomical Formulæ for Calculators SECOND EDITION
Jean Meeus
POCKET COMPUTER PROGRAMS FOR ASTRONOMERS
A COLLECTION OF 13 PROGRAMS FOR OBSERVERS, ASTRO-PHOTOGRAPHERS AND DOBSONIANS
FRED KLEIN

There are a lot of places you can buy a telescope.

Orion is the best. Here's why.

Low Prices

Orion's prices are among the lowest you'll find anywhere. Save hundreds of dollars on all the popular brands of telescopes. Big savings on accessories, too. And with our money-back guarantee on every purchase, you can't lose.

Huge Selection

We carry over 1,400 items — astronomical & terrestrial telescopes, binoculars, eyepieces, camera adapters, books & star atlases, electronic control systems, and many unique products you'll really like. Our $100,000 inventory and computerized inventory system means we'll probably have what you want in stock.

CELESTRON PRECISION OPTICS

ES Edmund Scientific

Meade

BUSHNELL

AccuTrack™

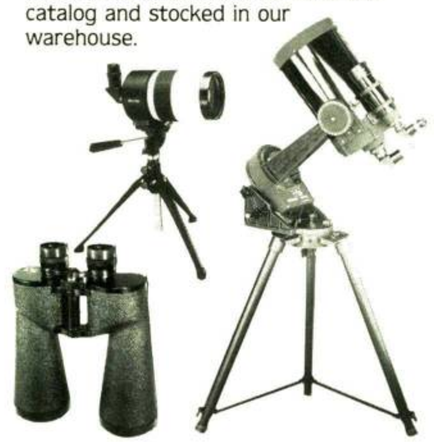
SWIFT

BAUSCH & LOMB

TeleVue

Major Brands

Celestron International. Meade Instruments. Bausch & Lomb. Edmund Scientific. TeleVue. Bushnell. Swift Instruments. Every major brand of telescopes and accessories available is listed in our catalog and stocked in our warehouse.



Fast Service

Our modern computerized order processing system gets your order to you fast — with next-day shipment on most orders. And if we can't ship your order right away, we'll send you a written confirmation with an explanation and a realistic shipping date.

Free Shipping

When you pay by check or money order, Orion pays shipping and insurance costs for you (USA only, except AK & HI). Shipping is extra on credit card or COD orders (and on a few very heavy items even if prepaid).

Honest Advice

We want to save you money, so we're happy to tell you what NOT to buy, if we feel a product you want is not right for your needs. We promise to never recommend a product just to make a sale. And if we don't have what you want, we'll suggest another company where you can find it. Let the telescope experts at Orion help you with all your telescope questions.

Free Catalog

Our giant catalog is filled with all the major brands of telescopes, complete accessory listings, and lots of helpful information to make your selection easier. Complete price list, of course. Why not call or write for your copy today?

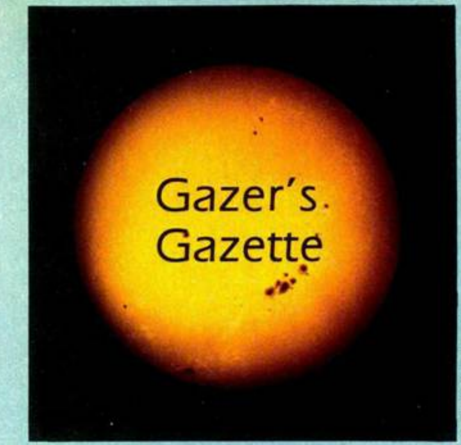
Toll Free! **800-447-1001**

IN CALIF. 800-443-1001

Serving amateur astronomers worldwide since 1975.

ORION
TELESCOPE CENTER
A division of Optronic Technologies, Inc.
P.O. Box 1158-A
Santa Cruz, CA 95061

Observing the Sun



A.W. Steinbrecher

Observing the Sun is a fascinating pastime — one that many telescope owners, faced with long, inconvenient drives to dark skies, might consider exploring as an alternative to mothballing their scopes for much of the time.

Unfortunately, most night-time telescopes are built all wrong for solar viewing. At night, you want aperture — and lots of it. After all, everything you're looking at (except the Moon) is pretty dim. Aperture confers a secondary benefit, too: as it increases, so does resolution — at least up to the point where seeing effects impose a limit.

So what do you get when you turn one of these telescopes on the Sun? Problems, that's what. To begin with, all that light-collecting power is pointless. Even worse, any scope that gulps in lots of sunlight is going to have a severe heat problem very soon. A colossal case of bad seeing quickly develops in the telescope tube as the warm air inside tries to flow out and cooler air burbles in to replace it. Even sealed tubes have air currents inside them driven by thermal differentials between the hot light-path and the cooler wall.

Help Your Scope Keep Its Cool

The best way to let your scope keep its cool while you observe the Sun is to stop most of the heat and light *before* it enters the optical system. Reflective over-the-aperture filters that do just this have become deservedly popular in the past 10 years. Such filters look like a flat mirror and consist of a layer of metal evaporated onto a transparent carrier such as thin plastic or optical glass. The coating is quite thin — often just a few microns — but this is enough to whittle down the incoming sunlight to a safe, small fraction.

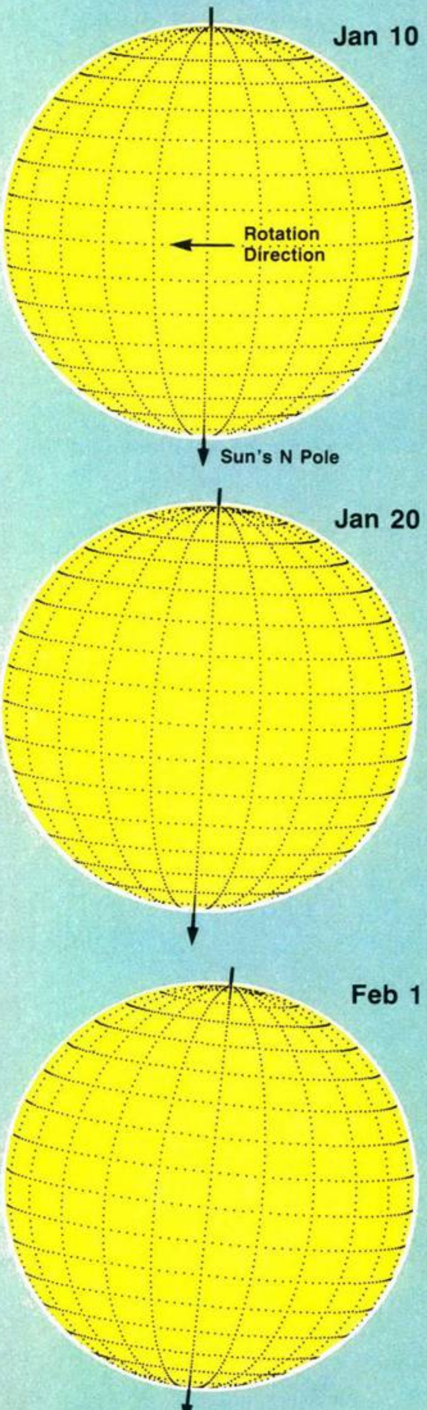
Don't confuse reflective filters with over-the-aperture filters, which work by absorbing sunlight. These become very hot and, moreover, do not stop all the invisible, but still damaging, infrared and ultraviolet radiation. You'll do well to forget them and stick to the metal-reflective kind.

As you'd expect, price is often a good guide to what you can expect in performance and durability. This isn't to demean inexpensive filters — it's just to make the point that some observers may not want to sink a lot of money into a Rolls-Royce-style filter they'll use only occasionally. But the more dedicated solar observer will naturally want the best he can afford.

What *is* the best filter? That depends on what you want from it. The properties of each type of coating affect how the image will look: plain aluminum coatings (usually on a Mylar carrier) give a bluish, low-contrast Sun. Another coating material, Inconel, produces a warm yellowish-white color that is more pleasing to the eye and gives greater contrast to features on the Sun's photosphere. The best filters are made from a sheet of optical glass whose sides have been ground accurately parallel to minimize distortion. Though expensive, one of these will last you a lifetime, given proper care.

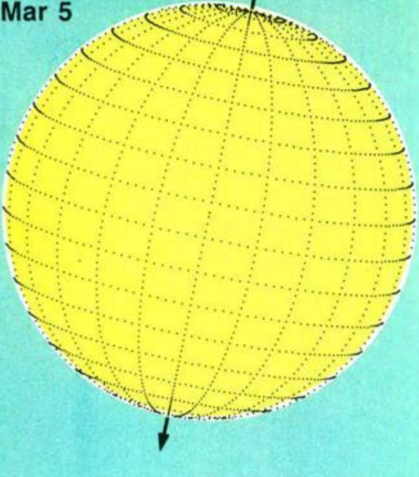
Loosely speaking, these are all "white light" filters: they transmit light over a relatively broad part of the spectrum. You can also buy more expensive special filters that transmit only narrow wavelengths — hydrogen-alpha, for example, for viewing prominences and other active regions (see "Shooting the Sun in H-Alpha," ASTRONOMY, July 1983). The techniques for using these are more complicated; in general, monochromatic filters are not transportable between scopes of differing f/ratios and focal lengths — you must buy one filter to use on one particular telescope. If you're a novice, give the monochromatic filters a pass — at least until your solar interests reach a level of involvement that justifies the expense.

"I have a 12-inch scope. Does this mean I have to shell out for a 12-inch filter?" No, it doesn't. There's no reason to buy a *full*-aperture filter when a smaller,

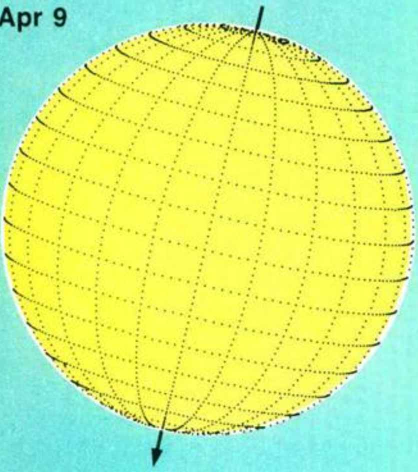


Because the Sun's rotation axis is tilted with respect to the Earth's orbit, we see a solar disk whose orientation is constantly changing. (South is up, to match the view in a telescope.)

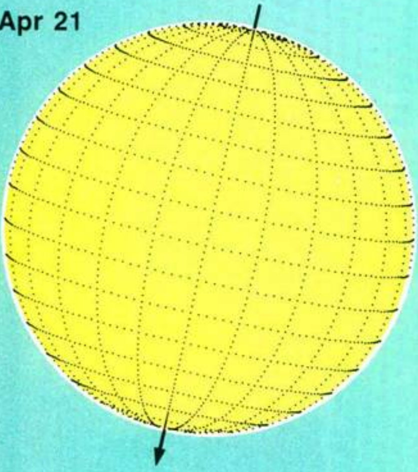
Mar 5

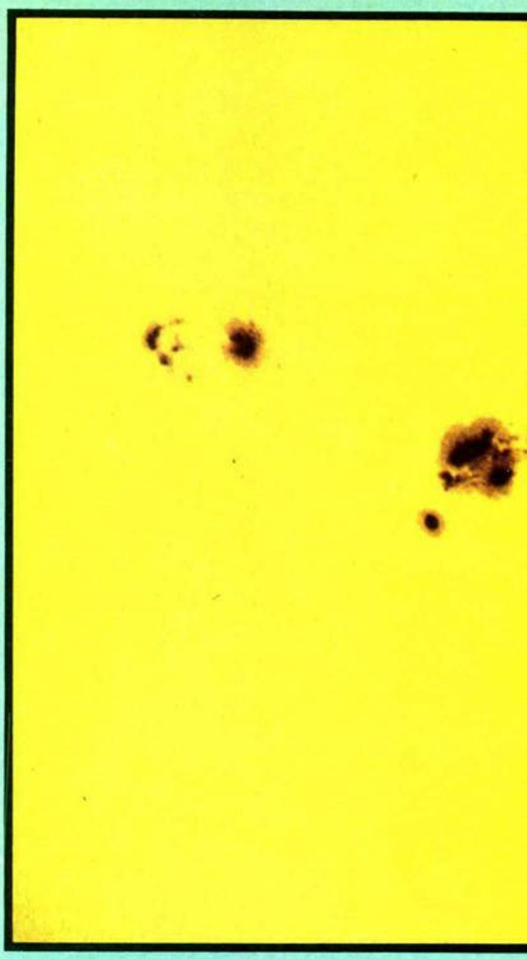


Apr 9



Apr 21





On April 28, 1984, a large sunspot group was crossing the disk. This group also produced the largest solar flare in six years. Photo by Jack Metcalfe.

subdiameter one will probably perform as well under most conditions.

Look in the front end of your scope. If it's a Newtonian, you'll see a secondary mirror mount and three or four vanes holding it in place. The spider vanes and secondary scatter light into the image and reduce its contrast — why filter them, too? Instead, choose the largest diameter circle that fits between the vanes, the secondary, and the tube wall. (In a typical 6-inch, for example, you could use up to about a 2.4″ diameter filter.) With Schmidt-Cassegrains, Schmidt-Newtonians, Maksutovs, and Astroscans, you have a window up front, but the same principle applies.

After you get your filter, make a big lens cap to fit snugly over the end of your scope. Illustration board, available in art supply stores, is easy to work and relatively durable. (Remember, though, to be sure to provide some way to hold it securely onto the scope. You don't want it blowing off in a gust of wind!) Paint the outside of the cap white and the inside flat black. Cut a hole the size of your filter and tape or epoxy the filter over the hole. Make sure the seal is good, the filter is squared-on to the optical axis, and there are no light-leaks around the edge.

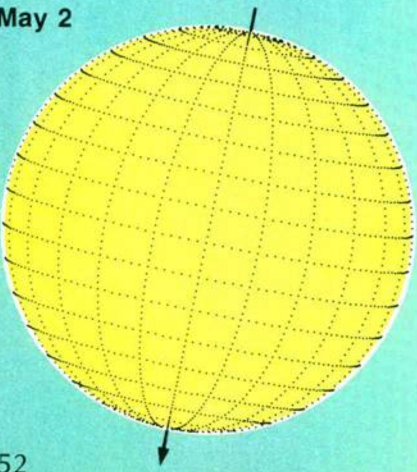
In effect, a subdiameter filter stops down your telescope: it converts a 12-inch, say, into a 3-inch or a 4-inch. This entails some loss of resolution, but as you may have found out already in night-time observing, images sometimes become crisper when you stop the scope down. This paradoxical improvement occurs because the cells of disturbed air that give rise to bad seeing are relatively small — a few inches across. Therefore a large telescope's primary optics always combine the distorting effects of several cells, and the result is a woozy image incapable of sharp focus. A small scope, on the other hand, has optics that look out through only one or two cells at a time. Here the image may not be very steady, but it will remain fairly sharp.

"I Can't Afford a Filter"

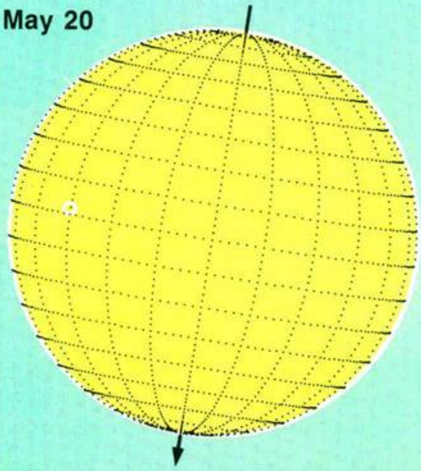
O.K., the budget's really tight — so what did astronomers do, back in the Dark Ages before reflective filters? Galileo used his telescope to project the Sun's image onto a piece of paper, and you can copy his method today quite easily. (Smart as he was, Galileo still committed an act of stupendous folly: he tried looking directly at the Sun though his telescope. This can *never* be done safely; don't ever try! You'll do painful, permanent damage to your eyesight. Galileo eventually paid the price, by the way — he died blind.)

Solar projection is totally safe, but

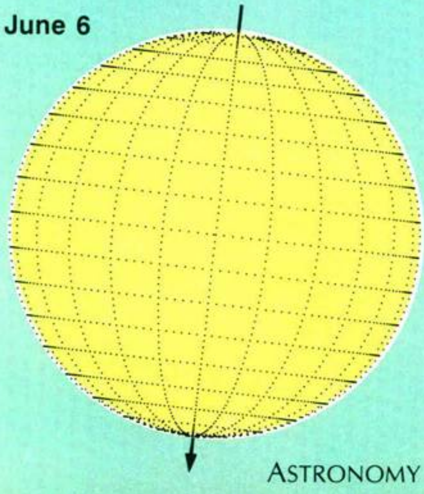
May 2

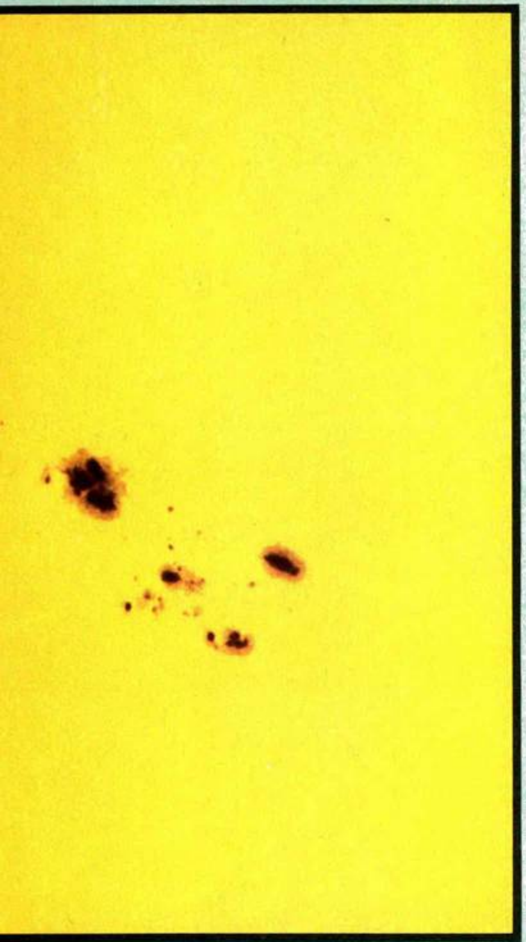


May 20



June 6





there's more to it than just setting up your scope and throwing the Sun's image onto a nearby wall. First, you must cut the amount of incoming light: stop the scope down with an off-center diaphragm. This is essential for your instrument's continued good health — a 6-inch mirror can easily ignite wood at the focal plane.

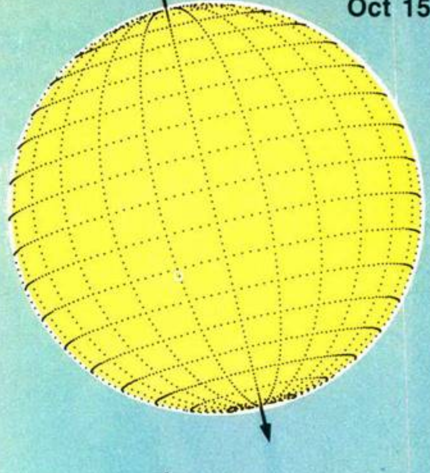
Then check your eyepieces. Those with cemented components are out, since the heat will "cook" the balsam cement between the elements, even when the scope is stopped down. Avoid Kellners, Erfles, Plössls, and orthoscopics; in their place use Huygenians or non-achromatic Ramsdens. You'll get better results with relatively low magnifications. Next, cover — or better yet, remove — the finder scope. *You're* not fool enough to try to look through it, but someone else might be. And besides, you could accidentally place some part of your own anatomy behind the eyepiece and . . . ouch!

Equatorially-mounted telescopes are easiest to use, once you get them aligned. Here's a tip for a rough-and-ready polar alignment: set the scope up on a clear night and align it on Polaris. Then place little splashes of paint (or drive big spike nails into the ground) where the tripod feet go. These will speed subsequent set-ups, and the alignment is adequate for solar observing. Should your telescope's mount be an alt-azimuth, don't worry — most solar viewing is done at low magnifications, and you won't find it hard to keep the Sun's image centered.

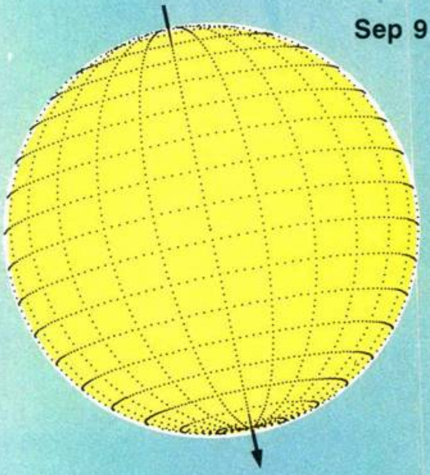
Centered on what, you ask? A piece of white paper, of course! But paper has little rigidity, so attach it to a clipboard for stiffness. You need one other modification — something to shade the projection sheet. Once again, illustration board is ideal; cut out a piece at least as large as the projection paper and then make a hole in the center the same size as the front of the telescope tube. Slip it on and check that it stays in place, using masking tape if necessary. (With a Newtonian, shade the *side* of your projection sheet.) Some telescopes — usually small refractors — come with a solar projection screen and Sun shield that clamp onto the tube. These are very handy, but often rather small. If you have one, modify it with a longer extension rod — a wooden dowel, say — and a larger screen and shade. If you haven't one, try making it out of dowels, stripwood, illustration board, and good ol' gaffer (duct) tape.

The first time you try observing like this, you'll think you're in charge of a three-ring circus all by yourself. Juggling scope, projection sheet, and keeping the Sun centered and focused will seem impossible. Aim at the Sun by looking down at the ground and moving the scope until its shadow is smallest. At times you'll just want to see if any sunspots are visible; then you needn't fuss much about the setup. But systematic observations are

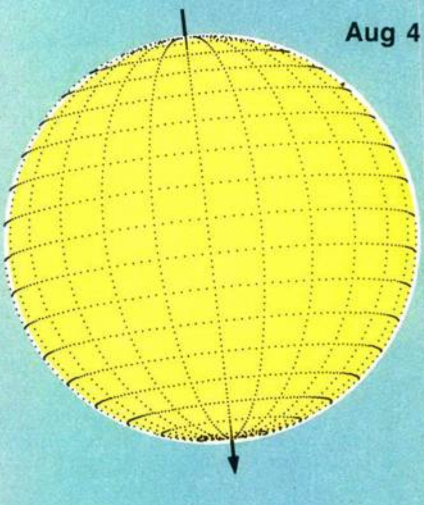
Oct 15



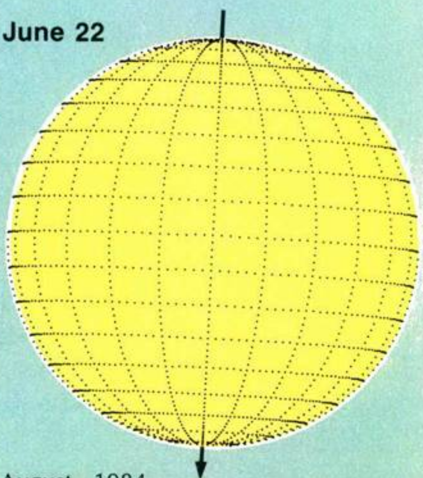
Sep 9



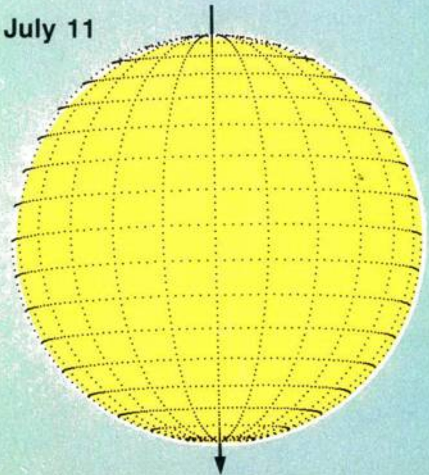
Aug 4



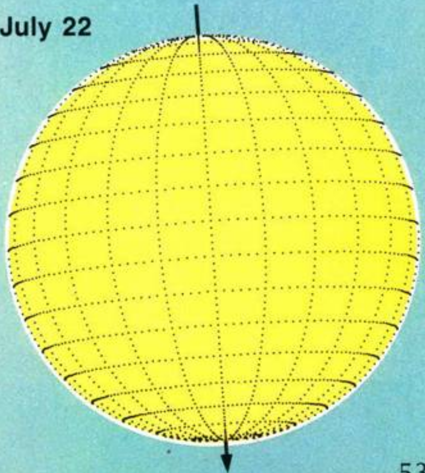
June 22



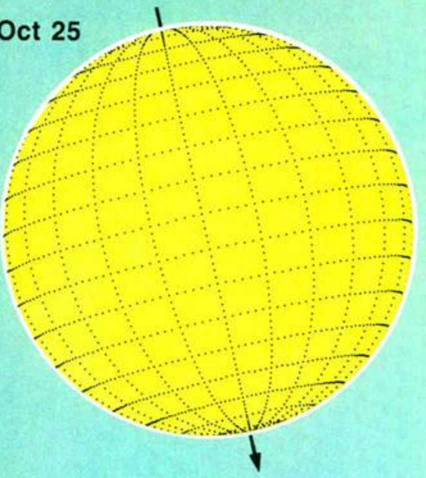
July 11



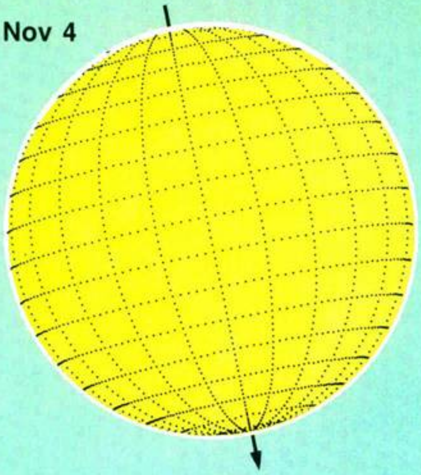
July 22



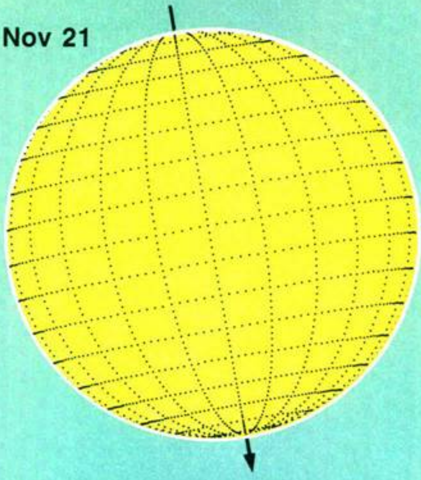
Oct 25



Nov 4



Nov 21



more fun in the long run, so work out a standard routine. Scribe a circle on the projection paper sheet about 8 to 12 inches in diameter. Next, throw the Sun's image onto the paper and adjust the distance and focus so that the solar disk exactly fills the circle. (This takes practice.) Then with a soft pencil draw in the locations and appearance of sunspots and other markings. To get the east-west direction, let the telescope drift. When you finish, label the sketch with north or south, date, time, instrument, and eyepiece.

Watch Out for Hot Air!

All solar observers encounter a common problem: bad seeing due to nearby warm surfaces. Perhaps the worst place to set up a scope is looking out over an area of blacktop pavement. You might as well try to observe across a stove with all burners going. The pros site their scopes with a careful eye to local seeing conditions — for example, one solar observatory is in the middle of Big Bear Lake in California. You probably can't duplicate this, but keep in mind that concrete beats blacktop, dirt beats concrete, grass beats dirt, and bodies of water beat grass. Time of day is also important; the air is often stillest soon after dawn, but you are then looking though a thick layer of atmosphere. As the Sun rises higher, the air mass decreases — but the seeing goes to pot as the air becomes warmer and less steady. Admittedly it's a trade-off — do the best you can.

What Is There to See?

The Sun's disk possesses an apparently sharp edge, the photosphere, but this isn't a surface in the ordinary sense. The photosphere is really a thin layer where the upwelling hydrogen gas cools just enough to become transparent.

To the backyard astronomer, the photosphere is where all the action is — and sunspots are the main attraction. These are regions of intense magnetic disturbance that appear brown or black only because they are about 2000° K cooler than the surrounding photosphere. They usually have a dark core, called the umbra, surrounded by a lighter penumbra. Sunspots tend to occur in pairs and groups; over the 12 days or so that they are visible on the disk, you can see day-to-day changes in their size, shape, and structure.

The Sun rotates in the same direction as most of the planets. Thus sunspots move across the face of the Sun, making one circuit in about 27 days as seen from Earth. (This figure is for spots near the equator; at higher latitudes it is closer to 14 days.) The average number of sunspots is now considerably less than at the maximum in 1980 (the next maximum is scheduled for 1991). Sunspot activity is worth monitoring, however, since large groups can still occur. In addition, you can also keep an eye open for the first spots of the next cycle, which will appear initially at high solar latitudes.

When you look at the disk, one of the things you see is that the limb appears slightly darker than the center. This effect comes about because we are seeing down to deeper, hotter layers in the center of the disk than at the limb. It also helps you observe some small bright mottlings called plages that usually occur near sunspots — but which are hard to view on the bright center of the disk. If the seeing is extremely good, also try looking for tiny, rice-grain-like speckles on the disk. These are convection cells of hot, upwelling hydrogen — each about the size of Texas!

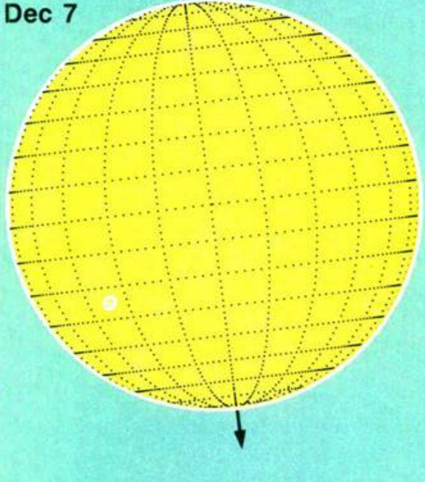
Lastly, always keep alert for flares. Most of these eruptions are visible chiefly in monochromatic light such as that of hydrogen alpha. (In fact, hunting for them is one reason amateur observers purchase $H\alpha$ filters.) But not all are monochromatic — on rare occasions, extremely violent white-light flares also occur. The particles hurled off the Sun in such a flare produce bright aurorae when they reach Earth about 18 to 48 hours after the blast.

* * * * *

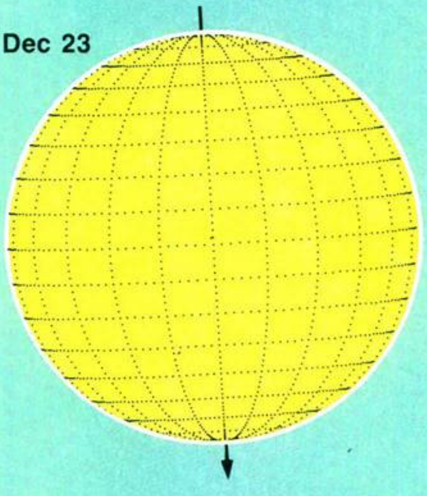
Though viewing the Sun calls for making some modifications to your regular observing rig, they are neither extensive nor costly. The reward lies in opening up a whole new field of activity for you and your telescope.

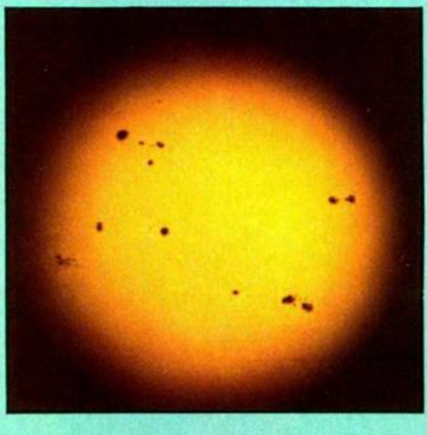
— *Robert Burnham*

Dec 7



Dec 23





Lee C. Coombs

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3.

LUMICON FOR HIGH PERFORMANCE

ASTROPHOTO OF THE MONTH

The "Dumbbell Nebula," M-27 in Vulpecula. The "ears" of the Dumbbell are seen best visually with a Lumicon UHC Filter. Photo by David Healy using a Lumicon Giant EASY-GUIDER and Lumicon hypersensitized 2415 film, 30 min., C-14 at f/6.

LUMICON® FILTERS

STOP LIGHT POLLUTION

The **LUMICON DEEP-SKY Filter**™ improves both visual and photographic contrast on all deep-sky objects, including galaxies. The **LUMICON UHC Filter**™ is for viewing only and yields the highest contrast for planetary and emission nebulae of any filter available today.

Filter Type	UHC	Deep-Sky
For 0.965" eyepieces	—	$49.95
For 1¼" eyepieces	$79.50	$59.50
48mm for 2" eyepieces	$119.50	$99.50
For 2" eyepieces & photography		$99.50
Set, 1¼" UHC & Deep-Sky Filters		$119.50
Selected premium filters		add $20

H-Beta Filter, 1¼" .... **$69** 48mm **$119**

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$29.95	$25.00
52, 55, 58, 62mm	$39.95	$29.95
67, 72, 77mm	$46.95	$39.95
82mm	$49.95	

Hypered 2415 film, 36 exp ... **$9.95** ... **3/$27**

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK

Plossl, Wide-Field, Nagler Eyepieces

7.4, 10.4, 13, 17, 21, 26mm Plossl(50°) ... **$65**
2½X Tele Vue Barlow Lens **$65**
32mm Plossl, widest true field in 1¼" .. **$80**
55mm 2" Plossl, widest possible field . **$160**
19mm Wide-Field, 1¼" eyepiece (65°) . **$110**
24mm Wide-Field, "superb" (65°) **$125**
32mm Wide-Field, 2" eyepiece (65°) ... **$195**
40mm Wide-Field, "awesome" (65°) ... **$250**
4.8mm Nagler, *82°* field **$125**
9mm Nagler, 82° field, "the best" **$195**
13mm Nagler, 82° field, 1¼" or 2" **$220**
(apparent field of view in parenthesis)

LUMICON®
2111 Research Drive #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add 6% ($20 for HYPER-KITS)
California Residents add 6% tax.
Prices subject to change w/o notice.

SUPER-FINDER™

The LUMICON SUPER-FINDER is both a compact Rich-Field Telescope and a magnificent "Super-Finder." It has a fully coated 80mm achromatic lens and 300mm focal length. The Deluxe SUPER-FINDER has a superb 500mm f/6 air-spaced lens.

12X80mm SUPER-FINDER **$169.50**
1¼" SUPER-FINDER w/o eyepiece **$149.50**
1¼" Right-angle SUPER-FINDER* **$149.50**
2" Right-angle SUPER-FINDER* .. **$179.50**
1¼" DELUXE SUPER-FINDER* ... **$239.50**
2"/1¼" DELUXE SUPER-FINDER* . **$289.50**
**Requires a 1¼" or 2" star diagonal*
1¼" star diagonal, 30mm aperture . **$28.95**
1¼" enhanced silver mirror diagonal . **$79.50**
2" LUMICON enhanced silver mirror-type star diagonal takes 48mm filters **add $99.50**
Mounting rings, 3-5/8" I.D. **$16.95/pair**
Mounting adapter for C-8, Meade, etc. . **$35**

CELESTRON SUPER C-8

Super Precision Byers Worm Gear Drive
• Precision Optics, Hand-Matched and Certified

HIGH PERFORMANCE 8" TELESCOPE SYSTEM (Black Super C-8 Shown) .. **$1350***
***Shipped F.O.B. Livermore, CA**

Includes your choice of a black or orange Celestron **Super C-8** 8" f/10 complete telescope system.

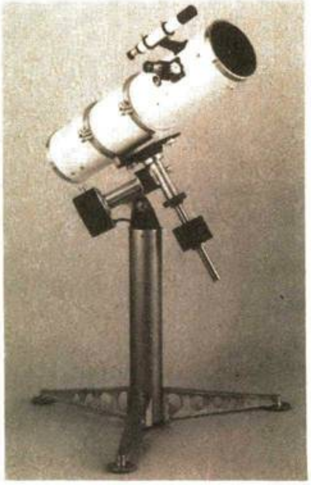
List price value = **$2030.** Includes a high precision 7" diameter Byers worm gear drive system ideal for astrophotography (10 arc second periodic error), high transmission coatings, 8X50mm right-angle finderscope, equatorial wedge, heavy-duty Meade adjustable field tripod, accessory tray, dew shield, no-tool knob set, deluxe latitude adjuster, 26mm (77x) multicoated Plossl 1¼" eyepiece, 7mm (286X) orthoscopic eyepiece, padded carrying case, all standard accessories, star map and finder cards for all the Messier objects. Shipping added ($30-$40) for charge orders.

OPTIONS BOOST PERFORMANCE

Starbright enhanced silver coatings boost visual transmission 10-15% (C-8 only) **$118**
LUMICON® Premium UHC Filter .. **add $79**
LUMICON® **Cassegrain EASY-GUIDER and** Rich-Field Viewer ($216 value) .... **add $198**
LUMICON Rich-Field Viewer, 2" aperture ... **$99**
Deluxe Piggyback Mount, adjustable **$39.50**
LUMICON Deluxe Rich-Field Viewer system w/ 32mm Tele Vue Plossl, 1.5° true field**$169**
200mm f/3.5 superb multicoated lens **$99.50**
Electric Declination for C-8 .... **$75**
Dual Axis Drive Corrector for astrophotography with electric declination **$248**

MEADE TELESCOPES

6" Newtonian $595



Meade 6" & 8" Newtonian reflecting telescopes include 6X30mm viewfinder, 1¼" focuser, 2 eyepieces, electric motor drive, setting circles complete mount & pier.

Model 628, 6"f/8 w/ motor drive, f.o.b. .. **$595**
Model 645, 6"f/5 w/motor drive, f.o.b. .. **$599**
Model 826, 8"f/6 w/motor drive, f.o.b. .. **$699**
Substitute #680 2" focuser .... **add $39**
Substitute 9X60mm viewfinder .... **add $85**
Dust covers (2): 6" ...... **$15** 8" **$19**
Accessory shelf **$28**
#47M dual-axis driver corrector and electric declination ($360 list) **$298**
LUMICON EASY-GUIDER™, 2" off-axis guider for perfect photos .... **add $129**
1¼" LUMICON UHC Filter™ ..... **add $79**

DEEP-SKY ASTROPHOTOGRAPHY

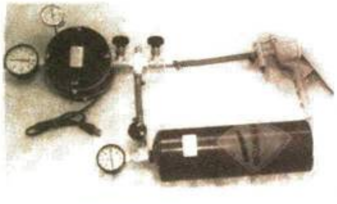
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer*, but it easy to use. Not recommended for 2415 .... **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$275.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$299.50**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$265.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER**™ off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*

†Patent Pending

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER **$139.50**
3X Relay Diagonal [See Photo] **$69.50**
Illuminated reticle eyepiece system . **$59.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$199.50**

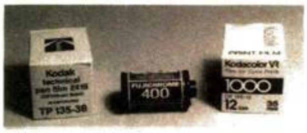
GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER [SAVE $20] ...... **add $79.95**

WHAT DO YOU NEED?

1. Hypersensitized Film. Use a LUMICON HYPER-KIT to insure a fresh supply, or use film pre-sensitized by LUMICON.
2. LED Illuminated reticle eyepiece system and battery pack, dual crosslines ... **$59.50**
3. Telescope with good drive. (See above)
4. Piggyback adapter (state telescope type)...**$25** Deluxe adjustable ...... **$39.50** 200mm f/3.5 multicoated lens........ **$99.95**
5. Filtration is essential for all lenses. Use hypered 2415 and the H-Alpha Pass Filter. For III a-J or color, use the Minus Violet Filter or the LUMICON DEEP-SKY Filter.
6. Off-axis guider is **essential** for consistently good prime-focus astrophotography.
7. Dual-axis drive corrector and electric declination (state telescope type)..... **$259**



HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. For fine grain B&W film use 2415. The fastest color films are Fujichrome 400 for slides and Kodak VR1000 for prints. Use VR1000 for galaxies and Fujichrome 400 for nebulae.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	$9.95
VR200 fine grain color negs	12	$9.95
Fujichrome 400, "Excellent"	20	$12.95
VR1000, fastest of all, color negs	12	$12.95
5072, color slides from negs	36	$6.95
D-19 B&W Developer, 1 gal.		$5.95

ASTRONOMY
Products for Observers

THE STAR BOOK
by Robert Burnham
AstroMedia / Cambridge University Press

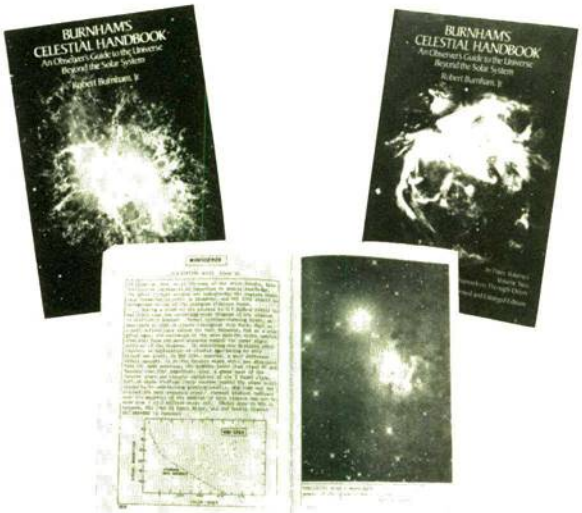
THE STAR BOOK

Learn the constellations with **THE STAR BOOK**, from AstroMedia. 8 charts cover all seasons, providing enough overlap for easy identification of prominent star patterns. Each map is accompanied by a description of the stars, the constellations and their lore and legends written by ASTRONOMY's Robert Burnham.

- **all northern constellations shown**
- **easy to use at night**
- **10" x 11¼"**
- **folds back for your convenience**
- **printed in two colors on thick cardstock**
- **coated with a durable water-resistant varnish**
- **heavy-duty wire binding**
- **will give years and years of service**

THE STAR BOOK......................$6.95

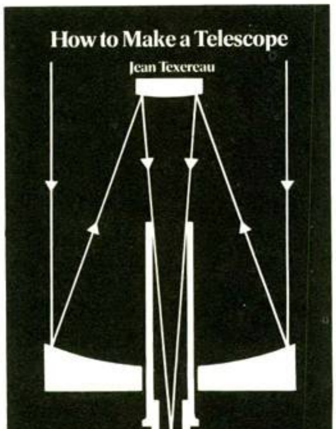
Foreign orders add $1.50


BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.

BURNHAM'S CELESTIAL HANDBOOK: Burnham. The great modern classic about deep-sky objects; each constellation has an introductory section with descriptions of double and multiple stars, variable stars, star clusters, nebulae and galaxies. Includes photographs, tables, graphs and finder charts — a must for your library. 3 volumes, 2138 pages in all, paperback.

Vol. 1 — Andromeda through Cetus
Vol. 2 — Chamaeleon through Orion
Vol. 3 — Pavo through Vulpecula

Vol. 1, $10.50; Vol. 2, $11.50; Vol. 3, $12.50


How to Make a Telescope
Jean Texereau
Second Edition

HOW TO MAKE A TELESCOPE, 2nd English ed.: Texereau. This 400-page treasure trove of techniques for grinding and figuring precision optical systems is a must for every budding amateur optical engineer. The expanded and improved second edition goes far beyond figuring the ordinary Newtonian, discussing the fabrication of Cassegrain primaries and secondaries, the Hindle test, and producing plano-parallel windows for high-performance systems. Includes BASIC programs for computing optical constants and reducing Foucault test data for both mirrors and windows. Comprehensive bibliographies of the literature from "Gleanings," Scientific American," and Telescope Making. This book is a must for the serious telescope maker. Hardcover.

HOW TO MAKE A TELESCOPE $19.95

Philips' Planisphere
Philips' Planisphere
Philips' Planisphere
Philips' Planisphere
Philips' Planisphere

PHILIPS' PLANISPHERES

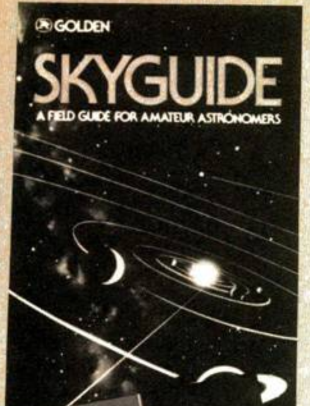
A **Philips' Planisphere** shows you the principal stars and constellations visible for every hour in the year. Just rotate the 2 plastic discs until the hour and date coincide. You can see what time Leo rises in mid-January, when the Pleiades set in May — "what's up" at any time, on any date.

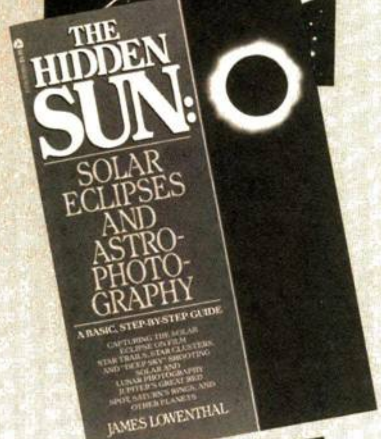
Lightweight and made of waterproof plastic, a planisphere is portable and durable enough to be taken anywhere — backpacking, sailing or your own backyard.

The 10" diameter size is available in 3 latitudes: 52°, 42° and 32°. The 5" pocket-size model is available in 42° and 32° ranges only. PLEASE SPECIFY LATITUDE.

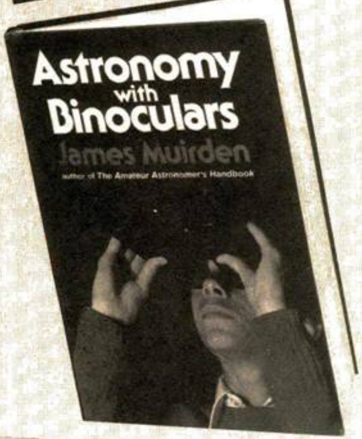
10" PHILIPS' PLANISPHERE 52°, 42° or 32° $8.95
5" PHILIPS' PLANISPHERE 42° or 32° . . .$5.95

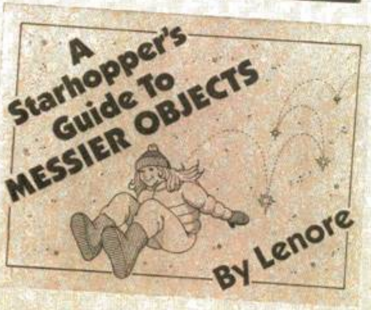
NEW! PHILIPS' DELUXE PLANISPHERE. For the travelling observer — 3 planispheres in one! Has the same high-quality features found in the standard models, PLUS interchangeable overlay discs for accuracy almost anywhere in the Northern Hemisphere. Includes snap-on overlays for 32°, 42° and 52° and comes in an album-style pouch. **$14.95**


GOLDEN
SKYGUIDE
A FIELD GUIDE FOR AMATEUR ASTRONOMERS


THE HIDDEN SUN:
SOLAR ECLIPSES AND ASTRO-PHOTO-GRAPHY
A BASIC, STEP-BY-STEP GUIDE
JAMES LOWENTHAL

starwatch
THE BEST, MOST COMPREHENSIVE YEAR-ROUND VIEWING GUIDE TO THE NIGHT SKY.
MAKE YOUR OWN EASY-TO-USE STARFINDER TO LOCATE CONSTELLATIONS.
BEN MAYER, A.R.C.A.


Astronomy with Binoculars
James Muirden
author of The Amateur Astronomer's Handbook


A Starhopper's Guide To MESSIER OBJECTS
By Lenore

SKYGUIDE: Chartrand. Subtitled "a field guide for amateur astronomers," the chapters include basic astronomy, telescopes and mountings — with detailed charts of each constellation, as well as color plates describing planets, stars, asteroids, eclipses, and more. 280 pages.

Hardcover $9.95 **Paperback $6.95**

OBSERVING VISUAL DOUBLE STARS: Couteau. Written by an astronomer who has discovered almost 2,000 double stars, Paul Couteau's book opens the way for any backyard observer who wants to share in the fascination of these beautiful stellar objects — and make a contribution to science. Full of practical advice and useful tables, this is a handbook no double-star observer should be without. 257 pages, paperback.

$9.95

THE HIDDEN SUN: SOLAR ECLIPSES AND ASTROPHOTOGRAPHY: Lowenthal. Whether you use the barest minimum of camera and tripod, or gear up with the latest and most sophisticated equipment, this clear and comprehensive manual introduces you to the exciting art of astrophotography. Starting with full instructions on photographing the "hidden Sun" — nature's most thrilling and awesome event, a total solar eclipse — Lowenthal goes on to include the Moon, planets, stars, and nebulae. If you've ever wished you could capture celestial sights on film, here's the book with the "how-to"! 107 pages, paperback. **$6.95**

ASTRONOMICAL TABLES OF THE SUN, MOON AND PLANETS: Meeus. With over 100 tables and graphs, details solar and lunar eclipses and lunar phases between 1951 and 2050, tabulates the occultations of planets and 1st magnitude stars between 1980 and 2000, and lists all planetary conjunctions between 1976 and 2025. Approx. 400 pages, paperback. **$20.50**

STARWATCH: Mayer. Graphically arresting and dramatically presented, **Starwatch** is a carefully thought-out and easy to use introduction to amateur astronomy. It showcases Ben Mayer's unique "starframe" concept — a simple yet innovative method for learning the sky. Profusely illustrated with clear line drawings and photographs. 144 pages, paperback.

$8.50

THE BEST DEEP-SKY OBJECTS: This handy card, printed on heavy stock and varnished for durability, shows where all the Messier objects are in the sky — plus the 51 best objects in the *New General Catalogue*. The front side displays them on an all-sky map (with an inset for the Coma-Virgo cluster of galaxies); the reverse tabulates each object and gives epoch 2000.0 positions, magnitudes, sizes, observing difficulty, type of object, constellation, and nickname.

$1.50 each or 50¢ each for 5 or more

ASTRONOMY WITH BINOCULARS: Muirden. The classic guide to sky-watching with the simplest equipment. Includes how to buy a good pair of binoculars and observing projects. 156 pages.

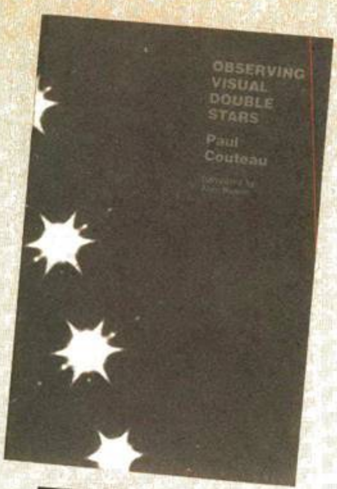
Hardcover $13.95 **Paperback $8.50**

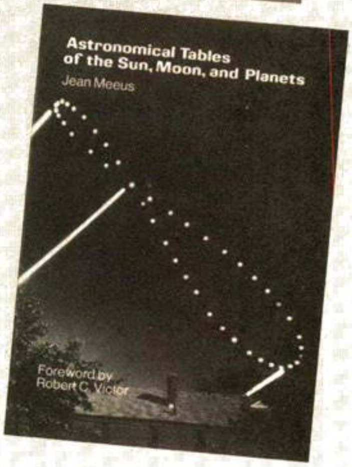
THE NATURE OF LIGHT AND COLOR IN THE OPEN AIR: Minnaert. A sky-watcher's classic for over 30 years! Tells all about "atmospheric optics" — rainbows, sundogs, mirages, multiple Moons, colored shadows, irridescent clouds, the green flash, and lots, lots more. Dozens of everyday atmospheric phenomena — and some which are quite rare — are clearly and simply explained. If you've ever looked at the sky and asked yourself "What causes that?" — here is the perfect answer book. 362 pages, paperback.

$6.50

A STARHOPPER'S GUIDE TO MESSIER OBJECTS: Freeman. Shows you how to locate each of the 110 Messier objects by "hopping" to them from easy-to-find bright stars. Uses only the naked-eye stars of each constellation. 23 pages, paperback. **$7.50**

To order any item on these 2 pages, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.


OBSERVING VISUAL DOUBLE STARS
Paul Couteau


Astronomical Tables of the Sun, Moon, and Planets
Jean Meeus
Foreword by Robert C. Victor

The Best Deep-Sky Objects

The nature of LIGHT & COLOR in the open air
M. Minnaert
mirages, haloes, shadows, double rainbows... hundreds of other phenomena visible with the naked eye ...explained by a famous physicist

ASTRONEWS

A European Mars Probe

The European Space Agency wants to get into the deep-space business, and is planning a probe to Mars. Such a mission has long preoccupied ESA — in fact, a 1980 report recommended development of a Mars "rover" starting in 1983. The mission now proposed — a result of feasibility studies submitted in January — will not be quite so ambitious, but if this scaled-down mission is approved, Kepler will be launched by Ariane in July 1988 and will arrive at Mars in January 1989. (The mission is named for Johannes Kepler, who used the motions of Mars to prove that the planets move in elliptical orbits.)

ESA is particularly intent on a mission to Mars because spacecraft sent by NASA and Interkosmos have mostly concentrated on imaging and the search for life. Kepler, on the other hand, will concentrate on collecting data on the internal structure of the planet by gravitational and magnetic field measurements and by examination of topographical features from orbit. This latter requirement will mean the spacecraft must have as low an altitude as possible (probably 150 kilometers) and a high-inclination orbit capable of enveloping the entire planet.

Little is known about the magnetic properties of Mars, despite all the previous missions to the Red Planet. In addition to its magnetic studies, Kepler's global mapping will complement gravity measurements by allowing researchers to examine crustal variations and to verify the existence of a fluid core. In addition, optical mapping in the infrared will provide information on surface temperatures, pressures, and dust cloud formation.

Earlier spacecraft have shown that the martian atmosphere consists almost entirely of carbon dioxide (with traces of oxygen and inert gases) and that the surface pressure is about one percent of that on Earth. Kepler will go further by monitoring Mars' global temperature field and atmospheric circulation. It will record daily and seasonal variations and determine water vapor distribution and evaporation. The composition of the upper atmosphere will be analyzed with mass-spectrometers and a variety of other test equipment.

After reaching Mars in 1989, Kepler would go into an eccentric polar orbit with a period of 4.8 hours. The nominal length of the mission will be one martian year: 687 terrestrial days. The spacecraft itself will consist of a cylindrical body 2.8 meters in diameter and 3.3 meters high, and will weigh 800 kilograms at launch (half this mass is propellant used for orbit insertion). It will have a spin rate of 5 rpm and will keep its spin axis pointed constantly toward Earth to ensure that the 1.5-meter high-gain antenna dish is always properly oriented. This unusual spin attitude will allow cheaper data transmission by not requiring a de-spun communications antenna. Also unusual will be the location of the solar panels: they will be disk-shaped and will surround the high-gain antenna.

Funding for Kepler, however, is up against another mission called DISCO, designed to study the properties of the Sun and its heliosphere. DISCO may receive funding at the expense of Kepler, because this Sun-study spacecraft will be able to operate along with the already-funded International Solar-Polar Mission spacecraft. But a delay for Kepler might prove beneficial, since it could give that mission time to evolve into the more difficult, and more rewarding, Mars rover. *Aldo G. Rabaiotti.*

A return to the Red Planet? The European Space Agency is considering a probe named Kepler, which could reach Mars by 1989. JPL/NASA Viking 1 photo.

Comet Kopff: Target for Rendezvous

A NASA scientific advisory group has recommended a relatively bright and active short-period comet named Kopff as the target for a rendezvous by a NASA spacecraft in the first of a series of proposed missions to primitive solar system bodies (comets and asteroids) and the outer planets.

This mission would use a new planetary spacecraft, the Mariner Mark II, successor to the Mariner, Ranger, Viking and Voyager spacecraft. (See "Return to the Planets," ASTRONOMY, September 1983.) Current plans call for the spacecraft to rendezvous with Comet Kopff in May 1994, after a July 1990 Space Shuttle launch. A rendezvous mission would differ from a flyby in that the spacecraft would match the comet's orbit around the Sun and then stay with the comet for several years. This extended encounter would allow a lengthy series of close-up observations.

The mission would be a follow-up to the flybys planned for 1985 with NASA's International Cometary Explorer (of Comet Giacobini-Zinner) and 1986, when European, Soviet, and Japanese spacecraft encounter Halley's Comet.

Comet Kopff, one of the brighter of the short-period comets, orbits the Sun every 6.4 years and has a perihelion 1.6 astronomical units out. (Aphelion is at 5.5 AU.) It has been observed by ground-based astronomers and by two spacecraft — the International Ultraviolet Explorer and Infrared Astronomical Satellite — when it was in the inner solar system last summer. The data show that Comet Kopff is somewhat dustier than most short-period comets.

The group chose Kopff because of its relatively active state and because the spacecraft will be able to perform the rendezvous maneuver more than two years before the comet's closest approach to the Sun. After rendezvous, the spacecraft will orbit the comet and examine it from ranges of less than 10 kilometers before the comet becomes active as a result of solar heating. When the comet has formed its coma and tail, the spacecraft will back off to continue operations in the dusty near-comet environment.

An additional attraction of the mission to Comet Kopff is the opportunity to take close looks at two main belt asteroids, Namaqua and Lucia, which the spacecraft will fly past during its journey out from Earth.

IRAS — A Sequel

Its supply of coolant exhausted, IRAS shut down last November (see "IRAS and the Infrared Universe," March 1984), ending the first — and very successful — infrared satellite observatory mission. To follow up on the results, several missions are being planned; among them is SIRTF (the Shuttle Infrared Telescope Facility). SIRTF may operate out of the Shuttle's cargo bay or, because the immediate environment of the Shuttle is not suitable for certain sensitive instruments, it may evolve to become a free-flying craft.

The European Space Agency is also planning an infrared satellite,

Celestial Objects for Common Telescopes

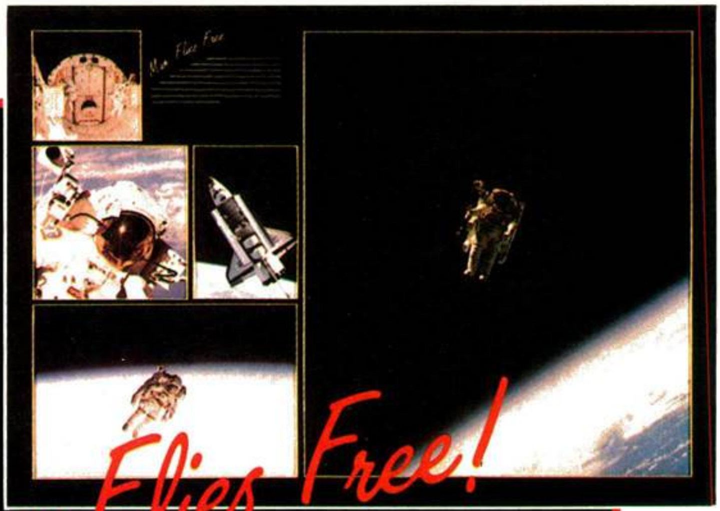
by T.W. Webb

Over the years, *Webb's* has been a treasured source for thousands of observers. This classic covers the solar system in Volume 1, and deep-sky objects (grouped by constellation) in Volume 2. Valued as much for its style as for its content, *Webb's* is a book for every telescope owner.

CELESTIAL OBJECTS FOR COMMON TELESCOPES
CELESTIAL OBJECTS FOR COMMON TELESCOPES
VOLUME TWO

606 pages
paperback, $11.00 (set)

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

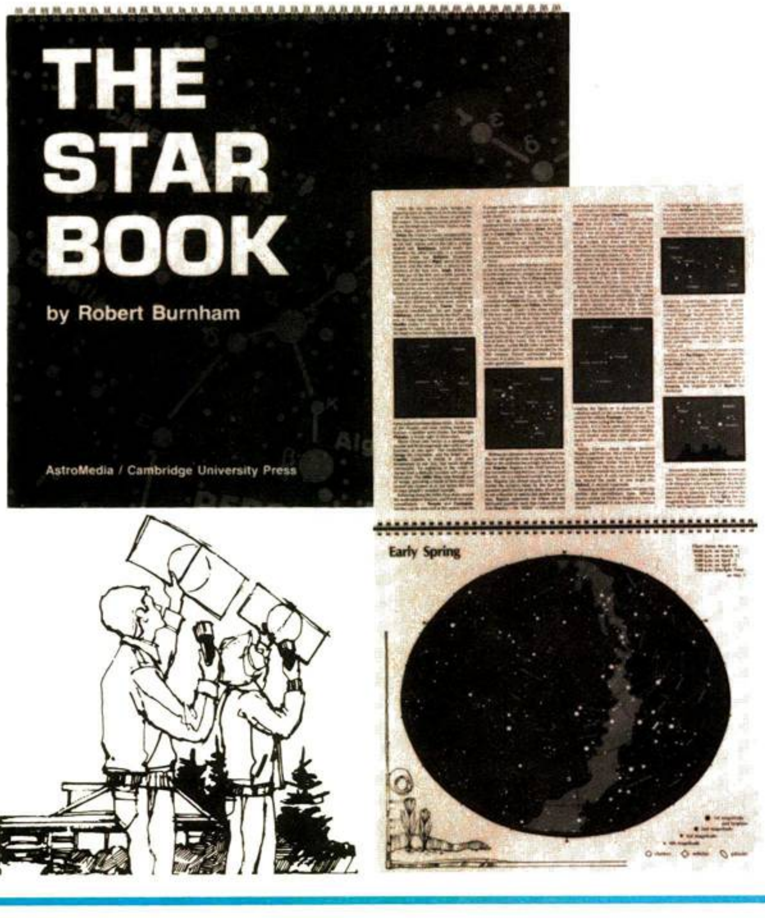

Man Flies Free

Man Flies Free!

Join the Space Shuttle astronauts on their first free-flying "space walk" with this colorful 21″ x 30″ poster. **MAN FLIES FREE** features breathtaking photographs highlighting the Shuttle's historic 10th mission, when astronauts successfully tested their jet-propelled backpacks. Order now!

MAN FLIES FREE	**$4.95**

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.


THE STAR BOOK
by Robert Burnham
AstroMedia / Cambridge University Press
Early Spring

Learn the Constellations with

THE STAR BOOK

Now ASTRONOMY's popular STAR DOME maps are available in durable book form. 8 charts cover all seasons and each map is accompanied by a description of the stars, the constellations, and their lore and legends written by ASTRONOMY's Robert Burnham.

- all northern constellations shown
- identifies galaxies, nebulae, clusters and major stars
- easy to use at night
- printed in two colors on thick cardstock
- coated with a water-resistant varnish
- heavy-duty wire binding
- folds back for your convenience
- will give years and years of service

THE STAR BOOK 10″ x 11¼″

$6.95

Foreign orders add $1.50

To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ASTRO NEWS

which will be launched in the late 1980s. ISO, the Infrared Satellite Observatory, will provide astronomers with a more sophisticated, highly maneuverable infrared telescope in space.

The spacecraft will be equipped with a 60-centimeter mirror, cryogenically cooled to offset thermal interference and provide a sensitivity close to the low natural limits set by astrophysical processes. Its makers hope that ISO will remain in operation for at least a year and a half.

ISO will offer a greatly improved sensitivity: 100 to 10,000 times better than a 4-meter ground-based telescope could achieve — though the sensitivity improvement depends on the wavelength and band width, the size of the astronomical source compared with the telescope field of view, and the efficiency of the instrument/detector. This upgrading is necessary to make infrared measurements comparable to those made in other regions of the electromagnetic spectrum.

Weighing almost two tons, ISO will be lofted by an Ariane-2 launcher into a 12-hour elliptical orbit having a 2,000-kilometer perigee, a 39,000-kilometer apogee and a 5° inclination to the equator.

A wide range of instrumentation specific to ISO is being developed and includes: narrow-band filters, continuously variable filters, photometers, interferometers, and spectrometers. The main scanning instrument — the 60-cm telescope — uses a novel mixed cryogen system, incorporating liquid helium and hydrogen as coolants. But in general, the aim is to use tried and tested technology wherever possible.

One of the many areas where ISO will have an important impact is extragalactic astronomy. Detailed spectroscopic observation of selected galaxies, especially the nearer and brighter ones, should enhance our existing information many times. Moreover, ISO's greater sensitivity will detect intra- and extragalactic dust, probe regions invisible to optical instruments, and help establish a new distance scale for the universe.

Star formation will also be investigated with an emphasis on the astrophysical "triggering" mechanisms that form a prelude to the embryonic appearance of a new star. Besides detecting the 3° K cosmic background microwave radiation, seeing into the universe's past means detecting very distant and highly redshifted galaxies. Here, normal optical spectra are shifted well into the infrared. An important, though speculative, prospect is that of extending this research to the observation of protogalaxies.

Project scientists will attempt to explore the chemical and elemental compositions of galaxies, as well as the missing mass problem, spiral galaxy halos, and dwarf infrared galaxies. Finally, within our own solar system, studies of the jovian planets, asteroids, and comets will all benefit enormously from ISO's high sensitivity. *Aldo G. Rabaiotti.*

Transatmospheric Vehicles

The Air Force's next generation fighter plane may be the last built to operate solely within Earth's atmosphere, according to an unnamed Air Force official quoted recently in *Aviation Week and Space Technology* magazine.

After several years of general studies, the Air Force is now beginning advanced work on what it calls a "Transatmospheric Vehicle," or TAV. The TAV would be a small spaceplane available in the mid- to late-1990s, capable of launching on five minutes' notice, delivering some 9000 kilograms to low Earth orbit, and returning. It may be capable of multiple reentries on a single flight, using the atmosphere to change its orbit and to dip low over a pre-selected target. The TAV would be entirely reusable; its primary purpose would be reconnaissance at an altitude too low for satellites, yet too high to be shot down easily. Other possible missions include "force projection, strategic defense," and bombardment from space.

Although the TAV is primarily intended for low Earth orbit, the Air Force has recently considered long-term development of a "space cruiser," an advanced spaceplane capable of operating throughout the Earth-Moon system.

In addition, *Soviet Aerospace*, a Russian military periodical, claims that these spaceplanes are intended to operate directly over the Soviet Union, to "counter Soviet antisatellite weapons," which have removed low Earth orbit as an "operating sanctuary."

The Air Force is also considering a second generation Space Shuttle similar to the current Shuttle in performance, but capable of rapid launch in difficult weather from dispersed locations and, in general, functioning more like an operational military transport aircraft than does the Space Shuttle.

Meanwhile, the Soviet Union recently performed the third successful test flight of a subscale model of their own spaceplane. The 900-kilogram satellite Cosmos 1517 is believed to have flown from Kapustin Yar on an SL-8 derivative of a intermediate range ballistic missile and, after a single orbit, to have landed in the Black Sea. The Black Sea landing may have been chosen because the Royal Australian Air Force managed to obtain some remarkably clear photographs of the first two test vehicles, which landed in the Indian Ocean on June 3, 1982, and March 15, 1983. The RAAF photographs — taken while shadowing the Soviet recovery fleet — appear to show a crew cabin and thermal protection tiles.

These tests are believed to be forerunners for an eventual 18,000-kilogram manned spaceplane, which may evolve into a vehicle remarkably similar to the proposed TAV.

Elsewhere, the Soviet Union's new "G" (Saturn-V class) rocket continues to sit on its launch pad; first launch is expected at any time. *Donald F. Robertson*

A New Telescope in Space

The advent of the Space Shuttle has had a great impact on astronomers and their instruments. More and more money is being invested in orbital observatories. The newest of these is the Far Ultraviolet Spectroscopic Explorer, or FUSE, described by W. Cash of the University of Colorado in a recent issue of the *Journal* of the British Interplanetary Society.

FUSE is intended to observe primarily in the spectral region from 912 Angstroms to 1200 A. This is an area almost unexplored, both because the equipment is difficult technologically and very heavy and, writes Cash, because "the high concentration of hydrogen and helium in the interstellar medium caused astronomers to predict that even the nearest stars would be obscured by interstellar absorption."

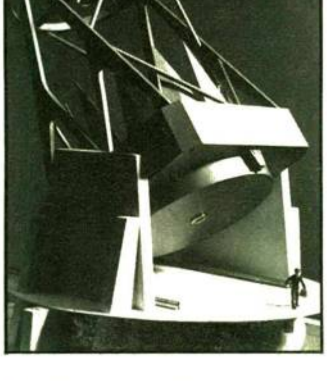
However, modern observations make it increasingly clear that the obscuration is not as bad as has been thought, and it should be possible to see far enough to observe all of the spectral lines which involve the ground state of hydrogen, and the Lyman transitions of atomic hydrogen and deuterium. These are important because "there are experiments to be performed in this region which cannot be done anywhere else in the spectrum, simply because most of the universe is made of hydrogen," Cash noted.

He further suggests that FUSE should be able to see the stellar winds and chromospheres of young and old stars, as well as quasars and aurorae on Neptune.

FUSE will also search for noble gases in the atmosphere of Titan. Minor modifications might allow FUSE to see from 100 A to 1800 A, covering both the extreme and far ultraviolets. This would let FUSE observe the chromospheres of hotter stars, hot white dwarfs, the hot interstellar medium, and possibly extragalactic targets, depending on how well the telescope can see through the interstellar medium.

Because of its high priority within the scientific communities of both Europe and the United States, and because of the expense engendered by the spacecraft's large size and tough pointing requirements (one arc-second in all three axes), Cash believes FUSE is a likely candidate for the next major collaboration in space research between these countries.

FUSE, says Cash, "would complement the tremendous power of the Space Telescope by operating in the bandpass just below the wavelengths where the Space Telescope ceases to operate efficiently." *Donald F. Robertson.*



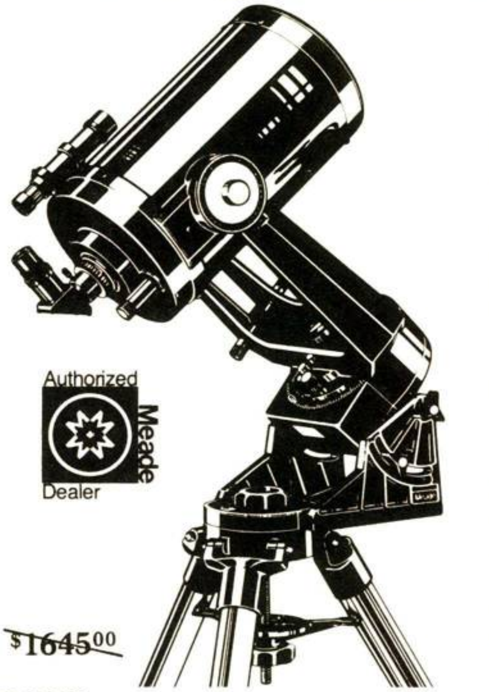
The "Eye of Texas" — a proposed 300-inch telescope for McDonald Observatory — faces funding difficulties and may be canceled. Photo from McDonald Observatory.

Funding Problems for the 300-Inch

A 300-inch telescope that has been on the drawing boards for several years at McDonald Observatory in western Texas is in danger of being shelved unless the University of Texas or the state of Texas soon makes a serious commitment to the instrument, according to the project director.

Gerald Carr, the former NASA astronaut who was hired as project

You get more for your money with Meade.



Compare the Meade 2080, left, with any comparably-priced competitive 8" Schmidt-Cassegrain telescope. Feature for feature, Meade gives you more. And Ad-Libs Astronomics gives you Meades for less!

Just look at the Meade 2080's standard equipment features . . .

- An oversize primary mirror — for brighter off-axis images.
- A spring-loaded focuser — to virtually eliminate image shift.
- Precision *worm-gear* electric drive — for sure, steady tracking.
- A rock-solid *adjustable-height* tripod that even holds your eyepieces.
- An equatorial wedge — with no-tool knob set, bubble-level, and latitude scale — that attaches to the tripod with just one fumble-free 3" knob.
- Setting circles, metal dust cap, slow-motion controls on both axes, 80x and 222x eyepieces, 6 x 30mm finderscope, foam-lined carrying case.
- Best of all, a **33% savings** and a **life-time warranty**!

Want some low-cost higher-performance 2080 options? Add $100 optical coatings — for a 10% increase in light transmission — for only $80. Or get the $2025 Meade 2080/LX2 *enhanced* package — with optical coatings, Research Grade eyepieces, *silver* and multicoated aluminum mirrors for 12% greater reflectivity, and an ultra-precise LX drive (warranted to *equal or exceed* the performance of any competitive worm drive) — for only $1394 at Ad-Libs Astronomics.

Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the more than 80 telescopes and 500 accessories we carry — from Meade, Celestron, Bushnell, Questar, Edmund, Coulter, Unitron, TeleVue, Lumicon, University Optics, and more — or send $1 for our complete catalog that takes the guesswork out of picking the right telescope and accessories!

~~$1645.00~~

$1099, plus freight

Prices good through 8/30/84.

ad·libs astronomics

2401 Tee Circle, Suite 106
Norman, OK 73069 (405) 364-0858
Now in our sixth year of saving you money! Mastercard, Visa.
North American sales only.

EASY TO ORDER . . . Phone or mail your order in today. Visa/Mastercards accepted. All telescopes and mounts are shipped shipping charges collect. All mirrors, except the 29", are shipped prepaid in the continguous U.S.A. No sales tax on out-of-state orders. FREE LIST.

Showroom address: 54140 Pinecrest Road, Idyllwild
Mon.-Fri. 8 am-4:30 pm. Sat. 12-4 pm.

ODYSSEY
Visual High Fidelity Telescopes

- **30 days returnable**
- **30 days exchangeable**
- **2 years materials and workmanship**

"NEVER TOO SMALL"

NEW! ODYSSEY 8 INCH

$239.50

"THE WORLD'S GREATEST TELESCOPE VALUE!"*

SPECIFICATIONS

- 8" f/4.5 paraboloidal mirror with matching diagonal flat, both 1/8 wave, aluminized and overcoated.
- Super smooth and stable Dobsonian alt-azimuth mount with linear U.H.M.W. bearings. No play or backlash.
- Adaptable to astrophotography with accessories.
- Coated high performance 27mm Kellner eyepiece with chromed brass and cast aluminum 1¼" rack-and-pinion focuser.
- Durable solid white seamless plastic vinyl tube.
- Adjustable ventilated push-pull shock resistant mirror cell.
- Beautiful black, white and metallic finish.

*Aperture is the key to performance. More aperture means more light and more resolution. In comparing all the small and medium size telescopes advertised in both Astronomy and Sky and Telescope magazines, we discovered that the Odyssey 8 has the lowest cost per sq. inch of aperture. The results were dramatic! One popular 4⅛" telescope costs $14.92 per sq. inch—3 times the cost of the Odyssey 8's $4.76 per sq. inch!

LARGE APERTURE

LARGE APERTURE is the key to the success of these fine telescopes. In their sizes, they are the largest-selling low-priced telescopes in the world today.

- 1/8 wave mirror optics
- Super smooth and stable Dobsonian mounts
- Adaptable to astrophotography with accessories
- High performance coated 27mm Kellner eyepiece with precision 1¼" focuser
- Beautiful Zolatone blue finish accented with black and metallic surfaces

10.1" ODYSSEY COMPACT

This scaled-down version of the Odyssey I performs very close to its larger brother. Because of its size, it is one of a few telescopes that can be used comfortably by an observer seated in a chair. Where space, size, weight and cost are considerations, this telescope will easily put you in the large aperture class. Fantastic views of galaxies, nebulae and star clusters are the menu of the telescope.

$299.50

13.1" ODYSSEY I

This is the telescope that started it all in the spring of 1980. Experienced deep-sky observers will tell you that you'll be amazed at what you can see under a good night sky. The challenge is not to see the lime-greens in M-42, but to detect the purple-pinks, the yellow-greens, and the subtle blues. In this size telescope there is not another available that gives you so much performance at such a low, low price.

$499.50

17.5" ODYSSEY II

Here is an unusual telescope at a low, low price. The core of this telescope is the world's most popular large aperture mirror set—the famous 17.5" f/4.5. Until recently this telescope sold for $1,195.00. We reduced the price $200.00. At $995.00 it is only $335.00 more than the mirror set! Shows colors in the Ring Nebula, two or three dust lanes in M-31, and globular clusters as they should be seen.

$995.00

29" ODYSSEY 29

The world's largest production telescope. It was with this telescope that we first saw color in the Veil Nebula. This telescope gives the observer an illusion of being in space more powerful than any other telescope we've observed with. Literally outperforms any other production telescope available in the world today.

$3495.00

Coulter Optical Co.

Dept. A, P.O. Box K
Idyllwild, CA 92349
714/659-4621

"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

ASTRONOMICAL OPTICS

Lightweight Mirror Optics at Low, Low Prices: Pyrex, ⅛ wave, aluminized & overcoated

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50
29 inch f/4.5 mirror with diagonal	$2490.00 16-1 Ratio
17.5 inch f/4.5 mirror with diagonal	$659.50 13-1 Ratio

Elliptical Diagonals

1.83"	$15.50	3.10"	$34.50
2.14"	$18.95	4.25"	$69.50
2.60"	$22.50	6.25"	$150.00

NEW! EQUATORIAL MOUNTS

- All metal
- 2" dia. shafts
- Hollow polar shaft
- Adjustable latitude
- Super sturdy, yet lightweight
- Single arm 10.1" mount
- Double arm 13.1" mount

Compact—$249.50

Odyssey I—$379.50

ASTRO NEWS

manager for the "Eye of Texas," says that to date only $1.3 million of an estimated $45 million necessary for the project has been raised. He hopes that a clear commitment to the new telescope by the university administration or the state government will make fundraising easier.

Carr says that the project would be phased out by the end of the year, since most of the preliminary engineering work has been done and there simply isn't enough money available yet to start more expensive next steps of the project.

One of the first disappointments for the project came about a year ago, when the state Senate Finance Committee canceled a $5 million appropriation for the project. Although committee members individually expressed support for the new telescope, the cancellation was made as part of a budget-cutting move to help the state meet reduced revenue projections.

However, Carr says, there is still hope that the university will supply additional funding. Peter Flawn, president of the University of Texas, has asked outside astronomers to review the project to determine its validity. The UT administration has reportedly discussed donating as much as $25 million to the project.

If built, the telescope would be the world's largest. The University of California and the National Science Foundation, however, are considering building a 10-meter telescope and a 15-meter telescope, respectively. The 300-inch "Eye of Texas" would be a 7.6-meter instrument.

Design work on the 300-inch by UT astronomers has been approved through contracts with Ford Aerospace Corp., Itek Corp., and Lockheed Optics. Plans call for the unusually thin, four-inch-thick mirror to be held in the proper figure with a computer-controlled support mechanism. The 300-inch telescope would boast the world's largest single-mirror instrument. Other large telescopes now on the drawing boards would use clusters of small, single mirrors to reach their full apertures. *Ray Grasshoff.*

ASTRO CALENDAR

July 28
Stellafane, Springfield, Vermont. Contact: Dennis di Cicco, 60 Victoria Rd., Sudbury, MA 01776.

July 28
Ohio Turnpike Astronomers Association Convention, Hiram College, Hiram, Ohio. Sponsored by the Cuyahoga Astronomical Association. Contact: Gary Kader, 2580 Northglen Dr., Westlake, OH 44115.

August 1-4
ALCON '84, National Convention of the Astronomical League, Carroll College, Waukesha, Wisconsin. Hosted by Milwaukee Astronomical Society. Contact: ALCON '84, P.O. Box 275, Mequon, WI 53092.

August 1-4
Astromart '84, an astronomy equipment fair held simultaneously with ALCON '84. Carroll College, Waukesha, Wisconsin. Hosted by ASTRONOMY Magazine. Contact: Dana-Lynne Terry, Advertising Coordinator, ASTRONOMY Magazine, P.O. Box 92788, Milwaukee, WI 53202. Phone (414) 276-2689.

August 6-10
Spitz Space Systems' Summer Institute in Planetarium Education, Chadds Ford, Pennsylvania. Contact: 1984 Planetarium Summer Institute, Spitz Space Systems, Inc., Rt. 1, Chadds Ford, PA 19317.

August 9-12
Convention of the Southeast Region of the Astronomical League, Pensacola, Florida. Co-hosted by Escambia Amateur Astronomer's Association and the University of West Florida. Contact: Merry E. Wooten, 6235 Omie Circle, Pensacola, FL 32504.

August 17-18
Near-IR and Solid-State Photometry Symposium, Lowell, Michigan. Hosted by IAPPP and Optec. Contact: Russell M. Genet, Fairborn Observatory, 1247 Folk Rd., Fairborn, OH 45324.

August 24-26
Connecticut River Valley Astronomers' Conjunction, Northfield Mountain Center, Northfield, Massachusetts. Contact: Jack Megas, 311 Surrey Rd., Springfield, MA 01118.

August 24-26
Starfest '84, Third Annual Observing Convention of the North York Astronomical Association, The River Place, Mount Forest, Ontario, Canada. Contact: Andreas Gada, 145 St. George St., Toronto, Ontario, Canada M5R 2M1. Phone (416) 922-6294.

August 28-September 2
Eighth International Planetarium Directors Conference (professional meeting), Stuttgart, West Germany. Contact: Dr. Hans-Ulrich Keller, Director, Planetarium Stuttgart, Neckarstrasse 47, 7000 Stuttgart 1, West Germany.

September 2-6
International Union of Amateur Astronomers General Assembly, Bologna, Italy. Contact: IUAA, C.P. 1630 AD, 40100 Bologna, Italy.

September 21-23
Astrofest. Sponsored by the Chicago Astronomical Society. Contact: Astrofest, P.O. Box 596-A, Tinley Park, IL 60477.

September 22
Ohio Turnpike Astronomers Association Convention, Akron, Ohio. Sponsored by the Astronomy Club of Akron. Contact: Philip Hegenderfer, 5070 Manchester Rd., Akron, OH 44319.

October 6
Astro Assembly, Seagrave Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. Contact: Gerald Dyck, 418 High Hill, North Dartmouth, MA 02747.

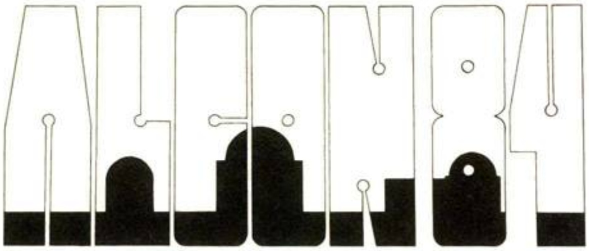
October 9-12
16th Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society (professional meeting), Kailua Kona, Hawaii. Contact: David Morrison, Institute for Astronomy, University of Hawaii, 2680 Woodlawn Dr., Honolulu, HI 96822.

October 13-16
Conference on the Origin of the Moon (professional meeting), Kona, Hawaii. Sponsored by the Lunar and Planetary Institute and the Division for Planetary Sciences of the American Astronomical Society. Contact: Pam Jones, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058. Phone (713) 486-2150.

October 19-21
Sixth Annual Custer Astronomy Club Jamboree, Southold, Long Island, New York. Contact: Warren E. Hamburger, President, 320 Asharoken Blvd., Bay Shore, NY 11706. Phone (516) 666-8654.

October 24-27
Great Lakes Planetarium Association Conference, Milwaukee, Wisconsin. Contact: Gary E. Sampson, Wauwatosa West High School Planetarium, 11400 West Center St., Milwaukee, WI 53222.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.



38th NATIONAL CONVENTION OF THE ASTRONOMICAL LEAGUE, MILWAUKEE AUG. 1 – 4

August 1 - 4, 1984
Carroll College • Waukesha, WI

Astronomical League 38th Annual Convention
Brought to you by the Milwaukee Astronomical Society in conjunction with A.L.P.O. Theme: "Astronomy — The Amateur Science." Four days of papers, speakers, workshops, displays, tours and observing.

— held jointly with —

ASTROMART '84

An Astronomy Equipment Fair
See what's available from manufacturers and retailers! Hosted by ASTRONOMY Magazine.

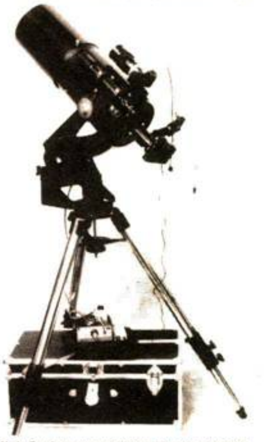
Write or call now for more information on travel discounts, dormitory accommodations, meals and tours:

ALCON '84, P.O. Box 275, Mequon, WI 53092
(414) 242-2369

MEADE TELESCOPES AT LUMICON

LUMICON carries a full line of Meade Telescopes and accessories. Meade catalogue $3. Call 415-447-9570 for latest discount prices.

HIGH PERFORMANCE SCHMIDT-CASSEGRAINS



High Performance 8"f/10 Meade 2080LX telescope system: (optional EASY-GUIDER, drive corrector, 200mm telephoto shown), includes high precision worm gear ideal for astrophotography (10 arc-second periodic error), 8X50mm finderscope, high transmission coatings, equatorial wedge, adjustable Meade field tripod, dew shield, accessory shelf, no-tool knob set, 7mm orthoscopic & 20mm research grade Erfle eyepieces, all standard accessories ($1759 value) . . **$1295**
NEW! Mirror enhanced coatings group adds 16-18% trans. Highly recommended **$99**

LUMICON Cassegrain EASY-GUIDER™
Rich-Field View combination ($216) . . . **$198**
Dual-axis Drive Corrector with electric declination **$275**
Deluxe Piggback bracket, adjustable . . . $35

NEW HIGH PERFORMANCE ACCESSORIES for MEADE 2080

Meade 2080LX with LUMICON 12X80mm SUPER-FINDER and LUMICON Rich-Field Viewer. Also fits Meade 2120, C8, C11, C14.

ENHANCED MIRROR COATINGS

NEW! High Performance Enhanced Mirror Coatings Group w/ enhanced alum. coated primary & enhanced silver coated secondary mirrors. Increase Meade 2080 trans. 16-18%. **Highly Recommended! . . . add $99**

LUMICON® 12X80mm SUPER-FINDER™
See galaxies & nebulae directly in the SUPER-FINDER. Includes removable 25mm cross-hair 1¼" eyepiece. D = 80mm, F = 300mm LUMICON SUPER-FINDER and deluxe LUMICON adjustable piggyback bracket. Removable to make a great compact portable telescope. Specify telescope type. Fits 2080, 2120, C-8, C-11, C-14.
Straight-thru 12X80mm system . . . **add $195**
Right-angle 12X80mm system . . . . **add $222**

Deluxe MEADE 2080LX Photo-Visual System
All features of the High Performance System described to Left, but with Enhanced Mirror Coatings Group, LUMICON 12X80mm right-angle SUPER-FINDER, Meade 6X30mm wide-angle finder, Meade Model 46 Dual-axis Drive Corrector and electric declination, LUMICON Cassegrain EASY-GUIDER/Rich-Field Viewer, Meade 12mm dual illuminated reticle eyepiece system, and LUMICON 1¼" Premium UHC Filter. **Deluxe Meade Photo-visual package** ($1006 value) . . . . **add $849**

Shipping added to telescopes, charge orders. Prices may change w/o notice.

LUMICON 2111 Research Drive, #5A
Livermore, CA 94550 (415) 447-9570

TeleVue™

Send for free guide: "Choosing Your Eyepieces"

Tele Vue 50°
PLÖSSL EYEPIECES

"SHARPEST I'VE EVER USED"

"Used with my 12" f/7, the Plössls deliver crisp images of the planets. I have the distinct impression that the eyepiece adds no optical errors to the image I'm viewing, and that I am seeing everything the mirror can deliver. This is an impression I've never had with any other eyepiece. Tele Vue Plössls are the sharpest I've ever used." —From review in August '81 "Astronomy"

New 4 element design improves performance of any telescope. Exceptional contrast and resolution over the entire 50° field, even with fast Dobsonians. Ideal for astrophotography too. Multi-coated. Chromed barrels threaded for filters.

55mm (2" barrel),
40mm & 32mm (1¼" barrel)

have widest fields possible for low power viewing. 7.4mm to 32mm models parfocal. 2.5x Barlow is a matched parfocal design. Actually improves eyepiece performance.

TELE VUE 32MM PLÖSSL

PLÖSSLS	
55mm	$160
40mm	80
32mm	80
26mm	65
21mm	65
17mm	65
13mm	65
10.4mm	65
7.4mm	65

BARLOW	
2.5x	65

Tele Vue 65°
WIDE FIELD EYEPIECES

A MAJOR NEW ADVANCE!

New 6-element design (pat. pend.) with a very wide 65° field. Significantly sharper than Erfles and König wide angle eyepieces. Field for field it rivals our Plössls. Almost essential for fast telescopes. Multi-coated.

40mm and 32mm Wide Field models have 2" barrels. 24mm and 19mm have 1¼" barrels and are parfocal with our Plössls. "First wide angle eyepiece with snap imaging." —John Vogt, New York

24MM WIDE FIELD

WIDE FIELDS	
40mm	$250
32mm	195
24mm	125
19mm	110

Tele Vue 82°
NAGLER EYEPIECES

EXPERIENCE A SPACEWALK!

Patented 7-element design introduces a new dimension in observing. Dramatically more field, sharpness and eye relief than any commercial eyepiece. Multi-coated. Dynamite with Dobsonians.

Naglers fit 1¼" barrels. 9mm and 13mm also fit 2" barrels. 9mm and 4.8mm parfocal too.

"With the NAGLER 9, the field is so wide and sharp in my C-8, the telescope seems to 'Get out of the way.' Amazing—a picture window with magnification." —Pat Walker, Virginia

TELE VUE NAGLER

NAGLERS	
13mm	$220
9mm	195
4.8mm	125

TeleVue PH. 914-735-4044
20-A DEXTER PLAZA, PEARL RIVER, NY 10965

All Tele Vue eyepieces sold with money back guarantee. Shipped postpaid in continental U.S. Residents of N.Y., please add sales tax.

ASTROMART

AstroMart listings are free to all our readers, but we can allow only 2 per person per year. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

Editorial Assistant

We are seeking a person for an entry level position in our editorial department. Duties will include key-entering, filing, correspondence, proofreading, and some writing and editing. An excellent opportunity for the right person.

Send resume and salary requirements to: Katherine Bond, Managing Editor, ASTRONOMY Magazine, 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202.

ADVERTISER LISTING

ADVERTISER	PAGE
Ad-Libs Astronomics	27,61
ALCON '84	63
ASTRO 64	65
Berger Bros. Camera Exchange	72
Bushnell	29
Celestron Int'l.	88
Cotton Expressions	65
Coulter Optical	61
Creative Fashion Eyewear	72
Dover Publications	64
Group Two	71
Int'l Seminar Programs	41
Jim's Mobile Industries	73
Los Angeles Optical	73
Lumicon	55,63
Meade Instruments	2-3
Meteorites	71
Nashoba Valley Travel	65
New England Astro-Optics	73
Optica b/c	73
Optics Ohio	65
Orion Telescope Center	50
Parks Telescope	31
Scharf Softwear Systems	65
Scope City	71
Star Tracker	72
TBR/OptiSystems	71
Telescopics	64
TeleVue	63,87
Texas Nautical	65
Tomlin — see Scope City	
Tuthill, Roger W.	48

ANNOUNCEMENT — Waterloo Amateur Astronomy Society has available astronomy programs for the Timex-Sinclair 1000 (ZX-81) and Atari computers. Includes Planet Finder and other useful programs. New members welcome. Contact W.A.A.S., 25 Bridgeport Rd. East., Waterloo, Ontario, Canada N2J 2J4.

ANNOUNCEMENT — Explore the skies of summer with the Rockland Astronomy Club at Lake Sebago Beach, Harriman State Park, New York. Friday, July 20; if Friday is cloudy, Saturday, July 21. Contact Rockland Astronomy Club, 110 Pascack Rd., Pearl River, NY 10965. Phone (914) 735-4163.

ANNOUNCEMENT — Tour the Milky Way with the Rockland Astronomy Club at Lake Sebago Beach, Harriman State Park, New York. Friday, August 17; if Friday is cloudy, Saturday, August 18. We'll be using "Homer," our club's 17.5-inch Dobsonian. Contact the Rockland Astronomy Club, 110 Pascack Rd., Pearl River, NY 10965. Phone (914) 735-4163.

ANNOUNCEMENT — The Baltimore Astronomical Society (second oldest in the United States) invites all to attend our meetings on the second Tuesday of each month, September through May, at 7:30 p.m. Meetings conducted at the Maryland Science Center, Inner Harbor, Baltimore, Maryland. For information contact the B.A.S., 601 Light St., Baltimore, MD 21230; or phone Dave Pessagno at (301) 526-5128.

ANNOUNCEMENT — The Pennsylvania Selenological Society welcomes into membership any amateur astronomer especially interested in the astronomy of the Moon and its exploration. A semiannual journal, *Selenology*, is included with membership, which is only $4 per year. Contact F. Graham, 417 Franklin St., Pittsburgh, PA 15112.

Free Dover Science Catalog
from America's leading publisher
of inexpensive science books.

Fully annotated guide to over 300 books, most under $7.00, on functions, differential equations, mechanics, relativity, astronomy, history of science, more—intermediate to advanced level. Write Dover Publications, Dept. A134, 31 E. 2nd Street, Mineola, NY 11501.

ANNOUNCEMENT — The Bridgend Astronomical Society meet on the first and third Friday of the month at the Recreation Centre, Angel St., Bridgend, Mid Glamorgan at 7:30 p.m. We extend a welcome to all astronomy enthusiasts in our area to join our society. Contact Mrs. Joan Pugsley, 3 ERW WEN, North Cornelly, Bridgend, Mid Glamorgan, United Kingdom. Phone 0656 742528.

ANNOUNCEMENT — The Astronomical Society of Kansas City meets on the fourth Saturday of each month. Meetings begin at 7:30 p.m. in room 103 of Royall Hall at the UMKC campus. Royall Hall is located between Rockhill Road and Holmes on 52nd Street. For information phone Gary Pittman at (816) 228-4238 or write the society at P.O. Box 400, Blue Springs, MO 64015.

ANNOUNCEMENT — The Southwest Washington (state) Astronomical Society in Olympia, Aberdeen, Hoquiam, and the Centralia-Chemalis region extends a welcome to all astronomy enthusiasts in our area to join our society. Contact Carl M. Newton, 2421 Leisure Lane, Centralia, WA 98531. Phone (206) 736-6144.

ANNOUNCEMENT — Planetarium internship: bachelor's degree and planetarium experience required. For details write: Intern Program, American Museum-Hayden Planetarium, 81st St. and Central Park West, New York, NY 10024.

ANNOUNCEMENT — The Mahoning Valley Astronomical Society would like to announce the Ohio Turnpike Astronomers Association meeting at Braceville, Ohio, on August 4, 1984. The event is sponsored by the Mahoning Valley Astronomical Society. Interested persons should contact Roy Mimna, 520 Meadowland Dr., Hubbard, OH 44425.

WANTED — Former space buffs and NASA employees who would be willing to donate old NASA or space-related publications and photos dealing especially with the earlier missions (Gemini, Apollo, etc.) to avid space buff. Any materials would be appreciated. I would cover postage. Contact Marge Meijer, 202 A-3009-56 Ave., Lloydminster, Alberta, Canada T9V 1Z6.

WANTED — Donations of back issues of ASTRONOMY for a library. We need 1973 through 1981. Please send sets of full years only. Donor's name will be placed in each book. Contact M. Peairs, 325 Highland Rd., Pittsburgh, PA 15235.

WANTED — Clock drive for Sans and Streiffe No. 618 equatorial, 76mm diameter. Contact E.V. Latham, 836 A. St., Washougal, WA 98671. Phone (206) 835-9315.

WANTED — Would like to purchase a 5" short-focus refractor as used in the Moon Watch program in the sixties. Contact Jack Green, 4 Dogwood Glen, Rochester, NY 14625.

STS-41D Emblem Features *Discovery's* First Flight

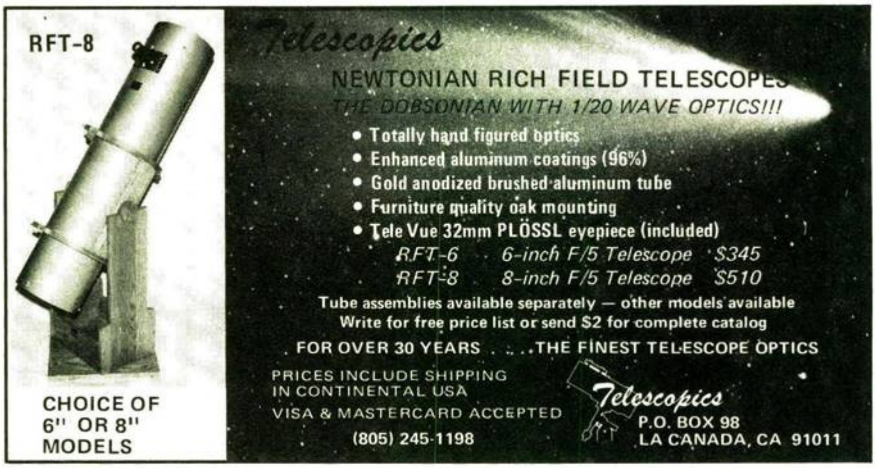
The Space Shuttle *Discovery* is pictured on this multi-colored embroidered emblem. NASA's official design shows the test of the solar array, which is designed to supply power for extended Shuttle missions. STS-41D's crew includes Judith A. Resnick, America's second female astronaut.

Wear some space history on your jacket or cap!

STS-41D 4" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

HARTSFIELD
COATS
MULLANE
DISCOVERY
HAWLEY
RESNIK
WALKER



RFT-8

Telescopics

NEWTONIAN RICH FIELD TELESCOPES
THE DOBSONIAN WITH 1/20 WAVE OPTICS!!!

- Totally hand figured optics
- Enhanced aluminum coatings (96%)
- Gold anodized brushed aluminum tube
- Furniture quality oak mounting
- Tele Vue 32mm PLÖSSL eyepiece (included)

RFT-6 6-inch F/5 Telescope $345
RFT-8 8-inch F/5 Telescope $510

Tube assemblies available separately — other models available
Write for free price list or send $2 for complete catalog

FOR OVER 30 YEARS . . . .THE FINEST TELESCOPE OPTICS

PRICES INCLUDE SHIPPING
IN CONTINENTAL USA
VISA & MASTERCARD ACCEPTED
(805) 245-1198

Telescopics
P.O. BOX 98
LA CANADA, CA 91011

CHOICE OF
6" OR 8"
MODELS

ASTROMART

WANTED — Telescope manual (or photocopy) for an 80mm telescope labeled "ATCO, New York 7, N.Y." Scope includes 4 lenses, erector prisms, right-angle mirrors, solar projection kit, screw-in Sun/Moon filters, etc. Pieces are missing. Contact John L. Todd, Jr., Rt. 4, Ripley, TN 38063.

WANTED — Donation of a 6" or 8" telescope. Any donations would be acceptable. Contact Reverend Larry Taylor, P.O. Box 945, Jamestown, NY 14702. Phone (716) 483-3895.

WANTED — *The Comet of 1577*, by C.D. Hellman. Contact L.J. Carter, The British Interplanetary Society, 27/29 South Lambeth Rd., London, SW8 1SZ England.

WANTED — I will buy your broken or damaged 35mm Miranda camera. (I need repair parts.) Interested in the following models: Miranda Laborec, Mirax Laborec, Miranda G. Also, focusing screens, critical viewfinders, and accessories for these models ("G" screens fit all three types). Contact John Allseits, 800 E. Allanson Rd., Mundelein, IL 60060.

WANTED — Information about where I can find film footage of Earth from space. Contact Mike F., P.O. Box 81, Belford, NJ 07718.

WANTED — Blueprints and specifications for an automatic electric driven mirror-grinding machine. Must be able to handle mirrors ranging from 12.5 to 24 inches in diameter. Contact Duane Frankson, 8019 Floral Drive, Spring Hill, FL 33526.

WANTED — Information regarding all aspects of computer applications to astrophotography and telescope control. Contact W. Furqueron, 12484 Abrams (2301), Dallas, TX 75243.

WANTED — Amateur observatory requires a moving-carriage comparator for measuring spectra on 4x5 plates. Must be in good working order, but age not important. Least count of 0.001 mm. Provide details and photo. Contact E.P. Majden, 1491 Burgess Rd., Courtenay, BC, Canada V9N 5R8.

WANTED — "The Bowl of Night," in mint condition, you pay shipping. Contact Anas Al-Ali, P.O. Box 2914, Sharjah, United Arab Emirates.

WANTED — NASA and Soviet space photos (lithos) and materials. Especially lunar landing EVAs, space walks, and single astronauts, American or Russian. Contact Jesse A. Sanchez, 408 Richburn Ave., La Puente, CA 91744.

WANTED — Official publications of NASA and ESA, including fact sheets and mission reports on all projects. Send list. Soviet literature also wanted. Contact Glen Morton, Sheffield Astronomical Society, 14 Homestead Close, Sheffield S5 0NE, United Kingdom.

WANTED — Books, documents, photos, and VHS tapes relating to Soviet space program. Any language okay. Send description and price to Steve Graham, Box 4586, APO NY 09109.

WANTED — Edmund Astroscan telescope in good condition. Contact Dave Buffington, 4171E King George Dr., Harrisburg, PA 17109. Phone (717) 787-5712.

FOR TRADE — Astronomy computer programs for Commodore Vic-20 or 64. I have programs for altitude-azimuth conversions, observing catalogs, precession and an ephemeris. Will exchange listings or cassette tapes. Contact Stephen K. Kysor, 11782 Bluejay Lane, Garden Grove, CA 92641.

FOR TRADE — Atari astronomy programs. Let's share; I know we have the best micro. Send your disk to Desta Elliott, 2153 West Cullom, Chicago, IL 60618. Phone (312) 525-3779.

FOR TRADE — 12½" f/8 Newtonian plus eyepieces, filters, solar filter, and pair of 20x60 binoculars — will trade for a C-8 with coatings, little accessories, worth $800. Contact Dale Dufresne, 419 Pine St., Norco, LA 70079. Phone (504) 764-7882.

FOR TRADE — New Celestron C-6 Newtonian with equatorial mount. Will swap for older model 6" or 8" Meade Cassegrain. Contact Bill Carpenter, P.O. Box 254, Lynchburg, TN 37352. Phone (615) 759-4489.

FOR SALE — ASTRONOMY back issues, about 80 copies — 3 from 1976, 8 from 1977, full sets thereafter. Make offer, plus UPS shipping. Contact Don Miller, 517 Accabonac Hwy., East Hampton, NY 11937.

FOR SALE — 2.6" elliptical, aluminized, quartz overcoated diagonal. Contact Brian Fearnow, Rt. 1, Box 169, Forest, IN 46039.

TEXAS NAUTICAL REPAIR CO.

Authorized Meade Dealer

COME AND SEE THE FINE TELESCOPES AND ACCESSORIES BY MEADE IN OUR SHOWROOM. WE HAVE IT ALL AND OTHER POPULAR MAKES.

3209 MILAM
HOUSTON, TEXAS 77006
(713) 529-3551

Master Card American Express Visa

NOVEMBER 22-23
ECLIPSE TOURS

We are offering one tour, which will be land based on Papua New Guinea, and a second aboard a ship sailing from Auckland New Zealand. Extensions to Australia, New Zealand, New Guinea, and other islands included.

(Note: Our NVTA eclipse tours are organized in cooperation with **Group Two**. Members of and correspondents with **Group Two** will automatically receive our NVTA information.) For details write:

Nashoba Valley Travel Agency
Box 977, Acton, MA 01720
617-263-7707

THROW AWAY YOUR ALMANACS, COMMODORE 64 USERS!!

Recently developed program accurately calculates sid. time, R.A., dec., alt./azm., rise/set times, and much more for Sun, Moon, and planets for any place, any time!

ONLY $19.95! Specify disk or cassette.
(PA residents add $1.20 (6%) sales tax)
ASTRO 64
120 Connie Park Dr., McKees Rocks, PA 15136

COTTON EXPRESSIONS
T-SHIRTS
$7.50 @ Men's S, M, L, & XL

27 DESIGNS
Send for **FREE** Catalog
Dealer inquiries welcome

COTTON EXPRESSIONS Postage: $1.50
832 W. Junior Terrace A5 1-2 Shirts
Chicago, IL 60613 ©1984

Announcing OPTICS OHIO
featuring TeleVue Optics
Plossls 50° field (except 40mm)

Focal Length	O.D.	Price
55mm	2.00"	160
40, 32 mm	1.25"	80 each
26, 21, 17, 13, 10.4, 7.4, 2.5x	1.25"	65 each

Naglers 82° Field of View			Wide Fields 65° Field of View		
13mm	2/1.25"	220	40mm	2.00"	250
9mm	2/1.25"	195	32mm	2.00"	195
4.8mm	1.25"	125	24mm	1.25"	125
			19mm	1.25"	110

SPECIAL OFFER: Any TeleVue order of $100.00 or more will get FREE metal carrying case ($55 value). Offer good through October 15, 1984. *complete catalog: $2.00

OPTICS OHIO
"A Division of Cosmic Connections, Inc."
P.O. Box 1439, Lancaster, Ohio 43130
Telephone inquiries accepted at our corporate office
312-851-5353

Used by elementary schools, universities, planetariums, and observatories worldwide.

YOUR WINDOW TO THE UNIVERSE

TellStar®

"This has really expanded my field of vision. I saw more in the six weeks after I got TellStar than I had in the six years before that."
Time/April 16, 1984

"This incredible program . . . gives you an accurate view of any starry night."
"TellStar is as valuable to the professional as it is fun for the amateur."
Personal Software/Feb. 1984

TellStar is your personal guide to the stars helping you discover the excitement of astronomy; whether you're 6 or 60. You will see, locate, and identify constellations, stars, planets, and other stellar objects with graphic displays.

	IBM/XT/JR	Apple II
⋆**Level I** One Star Table	$ 49.95	$39.95
⋆**Level II** Three Detailed Star Tables Including All Of The Fascinating 'Messier' Objects	99.95	79.95
⋆**Level II** IBM PC's Equipped With An 8087 NDP	129.95	n/a

Add $3.00 shipping and handling charges. CO residents include additional 6.1% sales tax. VISA and Mastercard accepted with signed order. International sales: please write. Dealer inquiries invited.

©1984 **Scharf Software Systems,** Inc.
Suite 1068, 2111-M 30th St., Dept. AS
Boulder, CO 80301 (303) 666-5353

VISA MasterCard

IBM and Apple are registered trademarks of International Business Machines Corp. and Apple Computer, Inc. respectively.

A Star that has Risen from the Dead

by
Sun Kwok

One night in September 1976, three Russian astronomers at the Piszkesteto Observatory in Hungary noticed a new star in the constellation Sagitta. A search through old photographic plates at the Sternberg State Astronomical Institute of Moscow University showed that the star was invisible — fainter than the magnitude limit of the plates — prior to April 1976. Then, between April and September 1975, its brightness rose by a factor of 40, from 16th magnitude to about 11th magnitude. As a result, O. Dokuchaeva of Moscow University issued a bulletin to alert international variable star observers. One of the most remarkable stars in the history of variable star research had just been discovered.

A search through the archives of photographic plates at the Harvard and Sonneberg Observatories confirmed the existence of a "new" star. But while a classical nova usually fades from its visual maximum after a few days, this star seemed to remain fixed at maximum light. In March 1977 it was officially given the variable star name HM Sagittae.

Shortly after its discovery, Richard Stover and Svein Siverstsen of the University of Texas obtained the star's spectrum. Surprisingly, its spectrum did not resemble that of a nova — it was full of bright atomic emission lines, which normally characterize planetary nebulae. Its nature totally perplexed astronomers.

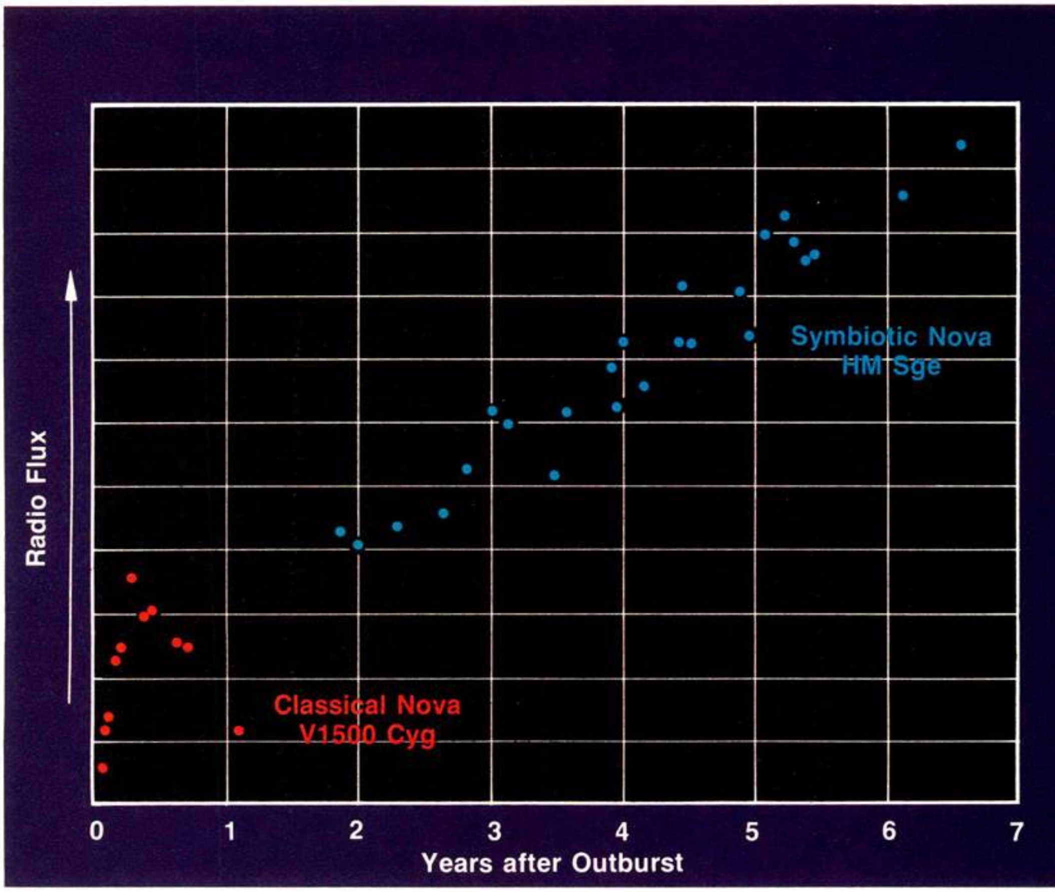
Strong emission lines in a stellar spectrum usually signify the presence of a gaseous nebula surrounding a star with a surface temperature of tens of thousands of degrees. By examining the relative strengths of different atomic lines, astrophysicists can determine the physical properties of the star and its surrounding nebula. This analysis showed that while HM Sagittae has a temperature typical of the central stars of many planetary nebulae, the density of its nebulosity is considerably higher. Since the density of a planetary nebula decreases as it ages and expands, astronomers suggested that HM Sge was a very young planetary nebula.

But in June 1977, Michael Merrill of the Mt. Lemmon Observatory made the first infrared observation of HM Sge. He found the star extremely bright in the infrared, the result of thermal emission from surrounding dust particles. His results indicated that the dust is made of magnesium silicates, which are commonly seen in very *cool* stars. Further observations by other astronomers detected carbon monoxide and water vapor in the stellar atmosphere. For these molecules to survive in a stellar environment, the star's surface temperature must be very low — no greater than 3000° Kelvin. (In comparison, the surface of the Sun is almost twice as hot.) Such a cool surface is usually associated only with red giants — stars well advanced in the late stages of stellar evolution, stars that have yet to create a planetary nebula.

The contradiction of temperatures for HM Sge seemed impossible to reconcile. But it brought to mind a class of strange stars discovered by Paul Merrill in the 1940s, which he called "symbiotic stars." Merrill coined this term for stars that display simultaneously the spectral characteristics of both hot and cool stars. At that time, about two dozen stars fit Merrill's description. Although most of them have no documented novalike outbursts such as that seen in HM Sge, a symbiotic star called V1016 Cygni did undergo a similar episode in 1964. Such outbursts may not, therefore, be isolated instances; they may represent a new, unexplained property of symbiotic stars.

In the late 1970s, when HM Sge began getting all of this attention, I had just published a theory on the nature of V1016 Cyg. I was therefore quite intrigued by this new discovery. Pim Fitzgerald, who discovered the 1964 outburst of V1016 Cyg, and Chris Purton, who measured radio emissions from that star, shared my enthusiasm; we decided to get together and tackle the connection between V1016 Cyg and HM Sge. The detection of radio emission from HM Sge by Paul Feldman of the National Research Council of Canada further convinced us of the similarity between the two stars.

We assumed that the sudden brightening of HM Sge was probably caused by the "creation" of a hot star — possibly the newly exposed hot core of a cool star. We also felt that the silicate dust particles seemed to be part of a strong stellar wind ejected



The radio emission of V1500 Cyg, a classical nova, rose and fell in less than one year. HM Sge, however, has continuously increased in radio brightness since its initial outburst in 1975. The decline in this symbiotic nova's radio output is expected to begin sometime this year.

from a cool star. Such winds are prominent in very old stars and constitute the most common means by which these stars lose mass before their eventual death. The radio emission could arise from a circumstellar envelope created by this wind — a shell of gas ionized by the hot star now present in HM Sge. We embarked on a long-term program to monitor the radio properties of this bizarre star to test our hypothesis.

Our observations at the Algonquin Radio Observatory in Ontario and the Very Large Array radio telescope in New Mexico confirmed the presence of a stellar wind in HM Sge. Furthermore, to our surprise, we found that the radio brightness of the star had slowly but steadily increased. Its brightness at a wavelength of six centimeters, for example, rose by almost a factor of three between 1977 and 1982.

Radio brightening in stars is rare but not unheard of. Classical novae have been known to go through a rise and fall in their radio power over the year following their outburst in visible light. The astonishing thing about this star was the long period of its increase. Extrapolation of our data shows that — as in classical novae — the radio emission will fall again, but probably not before 1984, nine years after its initial outburst. This discovery strengthened the ties between HM Sge and novae. We began to think that its resemblance to planetary nebulae was only superficial.

A planetary nebula is the outer part of a stellar atmosphere ejected into interstellar space near the end of a star's life, when it is a red giant. As this material expands into space, it exposes the core of the red giant, which becomes the central star of a newly formed planetary nebula. Intense ultraviolet light emitted by the extremely hot, exposed core ionizes the detached stellar atmosphere. Light emitted by these ionized atoms makes the planetary nebula visible.

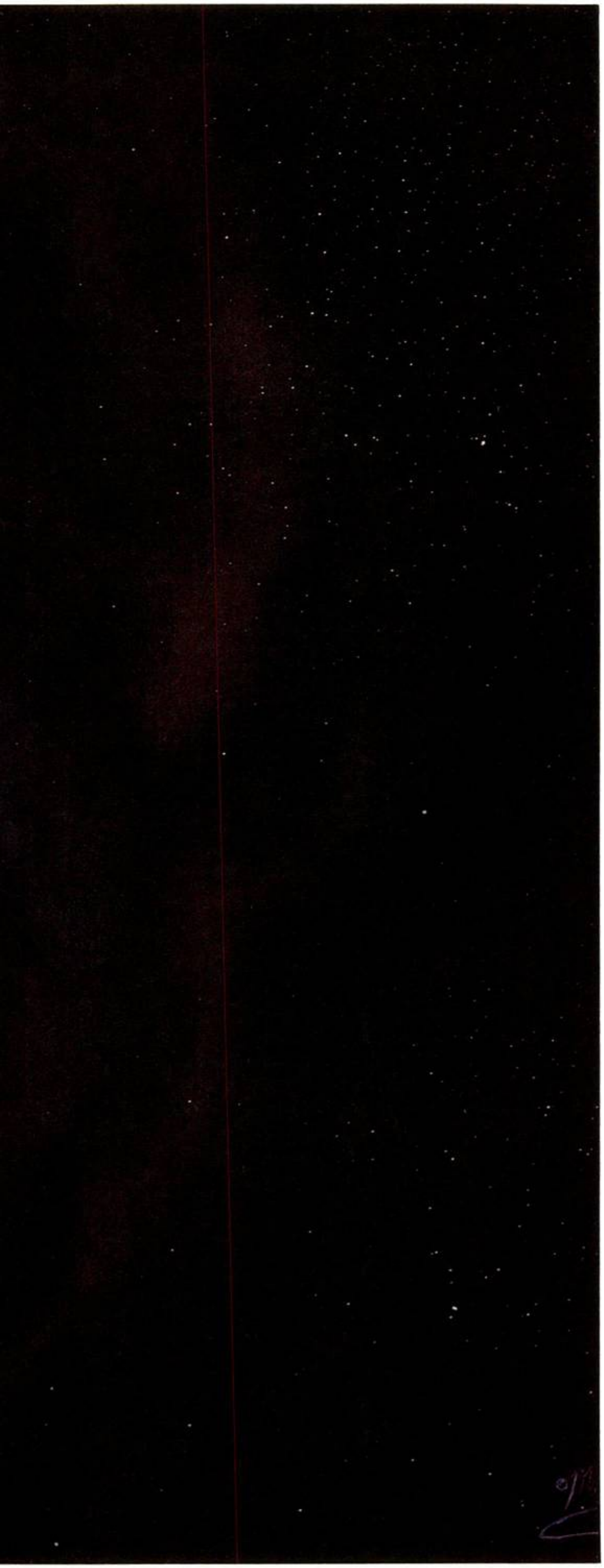
Traditionally astronomers believed that only Sunlike stars form planetary nebulae, but recent observations strongly suggest that stars with masses from one to eight times that of the Sun — over 95 percent of all stars — slough off their outer layers to create these objects. Most stars lose mass by means of intense stellar winds during their red giant phase; by the time they form a planetary nebula their masses are usually about 0.6 solar mass.

The central stars of planetary nebulae are mostly made up of carbon and oxygen, but maintain their luminosity by burning hydrogen on a thin surface layer. Even so, these stars can shine no longer than 10,000 years. They become hotter as the hydrogen is used up and the stars contract. These stars can have surface temperatures as high as 150,000° K, and shine exclusively in the ultraviolet. When the star finally exhausts its hydrogen reserves, its luminosity drops and it becomes a white dwarf.

The hot stars in symbiotic nova systems like HM Sge are similar to the central stars of planetary nebulae. They are small (a fraction the size of the Sun), hot (surface temperatures close to 100,000° K), and bright (several thousand times the luminosity of the Sun). Their hydrogen content makes up less than one percent of their stellar mass.

The launch of the International Ultraviolet Explorer (IUE) and the Einstein Observatory satellites in 1978 provided opportunities to study the ultraviolet and X-ray emissions from astronomical objects, something that is impossible to do on Earth because of the opacity of our atmosphere. During IUE's testing period, HM Sge was one of the first stars found to show a rich emission-line spectrum in the ultraviolet. And although this star was not on the high-priority observing list of the Einstein satellite, the instrument did detect X-ray emission from it. HM Sagittae was active in nearly all parts of the electromagnetic spectrum, from radio to X-ray wavelengths. In this respect, it is almost unique among stars.

Such a wide range of activity presents particular problems to the theorists who must account for them. To complicate matters further, most of the X-ray, ultraviolet, visible, infrared, and radio light we observe arises from the shell of gas and dust that surrounds the star; the star itself is nowhere to be seen. We can only infer the properties of the star, not measure them — a difficulty that makes astronomical detective work even more challenging. But after much discussion and debate, a consistent picture has gradually emerged from HM Sge's confusing clues.



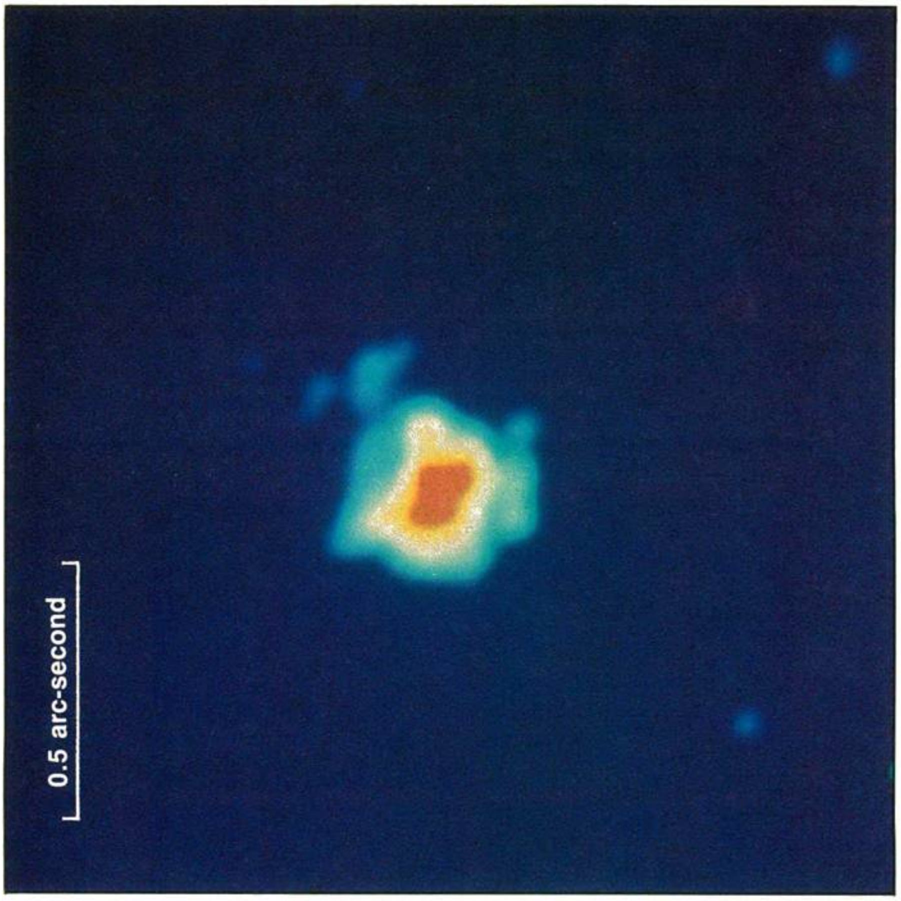
Symbiotic novae like HM Sge seem to be binary systems consisting of a white dwarf and a red giant. The white dwarf accretes matter lost from the red giant, and eventually this hydrogen-rich material begins to undergo fusion and explodes. The explosion ejects gas at speeds exceeding 2000 kilometers per second. This high-speed stellar wind from the white dwarf's hot surface soon collides with the slow, massive wind of its red giant companion. The interaction between these stellar winds creates a dense shell reminiscent of a planetary nebula. Painting by Michael Carroll.

The symbiotic nature of HM Sge is probably due to the presence of *two* stars, the members of a binary system. One is a white dwarf, a star that long ago finished its evolution and died (see the two articles on white dwarfs in the July 1984 issue); the other is a red giant entering the final phase of its life. As a red giant evolves, it grows bigger, brighter, and redder. At some point, its atmosphere becomes unstable and the star begins pulsating. Almost at the same time, the red giant develops a strong stellar wind, throwing off an immense amount of surface material into interstellar space. Although similar to the solar wind, the flow of charged particles emitted by the Sun, red giant winds are about one billion times stronger. According to some estimates, HM Sge may lose 500 trillion tons of matter every second — about one billion times that lost by our Sun.

The strong surface gravity of the white dwarf makes it easy for the star to capture some of the material streaming from its companion. Matter (mostly hydrogen) begins accumulating on the white dwarf's surface. Thousands of years later, enough captured material will have piled onto the white dwarf to produce the critical temperature and pressure for a thermonuclear explosion. Once ignited, the nuclear fires continue until all of the fuel is consumed. During this stage the white dwarf shines like a superhot star. Thanks to the outflow of its giant companion, the white dwarf has been given a brief new life.

This is what we now believe happened to HM Sge in 1975 and to V1016 Cyg in 1964. After nuclear burning commenced on the white dwarf, ultraviolet light emitted by the white dwarf began to ionize the stellar wind around it, creating the numerous atomic emission lines reminiscent of those found in planetary nebulae. Basically, atoms in this gaseous shell convert the ultraviolet light of the white dwarf into visible light, giving the system the appearance of a six-magnitude increase in visual brightness.

The emission of ultraviolet light from the white dwarf is accompanied by a stream of particles expelled from the stellar surface by radiation pressure. The speed of these particles can reach thousands of kilometers per second. They slam into the



A radio "photograph" of HM Sge made with the VLA. The overall size of the object is less than half a second of arc. The extraordinarily high resolution (0.06 arc-second) of the telescope enables astronomers to distinguish the shell (orange) from the red-giant wind (white).

wind from the neighboring red giant and sweep up the material like subatomic snowplows. The amount of matter in the swept-up pile of high-density gas increases rapidly and produces the rising radio emission we observe. By carefully analyzing the emission lines from different atoms, Lee Ann Willson of the State University of Iowa and George Wallerstein of the University of Washington confirmed the existence of the snowplow picture.

Further support of this scenario came in 1982, when Carl Bignell and I took a radio "photograph" of HM Sge at the Very Large Array. Observing at the high frequency of 22 GHz and employing the VLA at its largest configuration, we achieved a resolving power of 0.06 arc-second, or about 20 times better than can be obtained on a large optical telescope. Even though the star's nebula is only a few tenths of an arc-second in size, we were able to discern the red giant wind *and* the high-density shell created by the snowplow process. There is now no doubt that the two stars of this system interact via stellar winds.

Classical novae are also binary systems containing a white dwarf, but there are major differences between symbiotic novae like HM Sge and classical novae. The companion star in a classical nova is a red dwarf, a main-sequence star somewhat less massive than our Sun. When the white dwarf is ignited in a nova outburst, it completely overwhelms the red dwarf's feeble glow. In a symbiotic nova, however, the white dwarf is accompanied by a red *giant*, a star of comparable intrinsic brightness to the white dwarf — even at the peak of the dwarf's outburst. This is what creates the puzzling hot-cool spectrum.

Another difference between these systems is that the red dwarf of a classical nova system does not possess a powerful stellar wind. Although the speed of the red giant wind is lower than that of its white dwarf companion, its mass ejection rate far exceeds that of the much denser white dwarf. It's as though the two stars are engaging in a contest with their respective stellar winds, generating X-ray emission and creating the gaseous shell in the process.

It is a remarkable coincidence that the two stellar components of a symbiotic nova — white dwarf and red giant — are, respectively, the descendant and progenitor of planetary nebulae. When the white dwarf is re-ignited, it "evolves backward," once again becoming the central star of a gaseous nebula. Once the nuclear reactions on its surface stabilize, the white dwarf will evolve normally — just like the central star of a planetary nebula — until it exhausts its nuclear fuel. The white dwarf just retraces its own steps.

Of course, the circumstellar nebula that looks so much like a planetary nebula is formed by the red giant member of the symbiotic system. In a real planetary nebula, the material was ejected when the star was a red giant, then illuminated when that star evolved into a white dwarf. Symbiotic novae just split these roles between two stars. This explains the resemblance between symbiotic novae and planetary nebulae. From an evolutionary point of view, however, they are really more closely related to the systems that produce classical novae.

Stars live finite lives — perhaps 10 to 15 billion years for a low-mass star like our Sun, or a brief flash of glorious existence lasting less than a million years for a really massive star. A lucky few, born with twin brothers in the right range of masses, may rise again and relive part of their later lives by capturing fuel from their companions. This act of resurrection may even occur more than once if the giant companion lives long enough.

The model I've described probably doesn't represent the last word on this exciting phenomenon. But as someone who has puzzled over it for the last seven years, I cannot help but feel that the recognition and modeling of this system was possible only because astronomers have access to the whole electromagnetic spectrum, not just a narrow view confined to visible light. Understanding the symbiotic nova was truly a cooperative effort by astronomers of different specialties working together and sharing information. With the prospect of more and more telescopes stationed in space, this may represent a preview of the way we do astronomy in the future.

Sun Kwok, an astrophysicist at the University of Calgary in Alberta, specializes in the study of the late stages of stellar evolution.

ASTROMART

FOR SALE — 4" f/7 homemade refractor on commercial equatorial mount and wooden tripod. Includes 3 eyepieces, Barlow, star diagonal. In good condition, $200 or best offer. Contact Ray Howard, 4815 Clayton #126, Concord, CA 94521. Phone (415) 825-5209.

FOR TRADE — Soviet space pins for back issues of ASTRONOMY, *OMNI*, *Science Digest*, *Future Life*, *Discover*, etc., also science fiction books. Contact Leonard Peltier, 644 Isbister St., Winnipeg, Manitoba, R2Y 1R1, Canada.

FOR SALE — Astrophotometry equipment. Micro-microammeter, Keithley model 4140, 10mA to 0.1pA in 17 steps; high voltage supply, Hamner model N-4035, 3250 VDCmax, 20mA; strip-chart recorder, Linear model 212, 100mA FS, single chart speed; each above unit $200 or $500 for all three. IC tester, Beckman model 999, $300. Will ship COD. Contact G. Chaplenko, 73 Alexander St., Edison, NJ 08820. Phone (201) 549-0615.

FOR SALE — *Sky & Telescope* back issues, February 1973 through January 1984. 132 issues, excellent condition in file folders by year. Best offer in month of ad plus shipping. Contact A.S. Blood, RFD 5, Box 276, Augusta, ME 04330. Phone (207) 622-3893.

Eclipse	Eclipse

Expeditions
1983 June 11 1984 November 22/23

1984 at Papua New Guinea site surveyed 1982-3-4

1984 also by ship northeast of New Zealand

Information from:

Group	Two

Box 199
Bedford, Massachusetts 01730
617-275-7373

FOR SALE — Model 2200 Accutrack auto tracker. For use with Accutrack drive speed control, could be modified for other drives. Very good shape, $80 or reasonable offer. 1.37" diagonal in spider for 9" tubing, may need resilvering, $15. Postage included. Contact Brad Timerson, 623 Bell Rd., Newark, NY 14513.

FOR SALE — *Sky & Telescope* back issues, December 1973 through January 1977, November 1979 through November 1980, and February 1981 through February 1982. $50 for all, or $1 each. Write Box 10601, White Bear Lake, MN 55110. Phone (612) 429-4358.

FOR SALE — 18th, 19th, and 20th century astronomy books. Works by Schroter, Flammarion, Proctor, Schiaparelli, Antoniadi, Lowell, etc. For list of over 100 items send long SASE to Stan Kiser, Route 4, Box 203, Vale, NC 28168. Phone (704) 276-2666.

FOR SALE — Kodak Aero-Ektar lens, 24' f/6 in barrel with diaphragm. Needs cleaning. $60 plus shipping. Contact Keith Gordon, Box 44, Munsonville, NH 03457.

FOR SALE — Star Instruments 6" RFT reflector. No stand, hand-held, Pyrex mirror, fiberglass tube, 1¼" rack-and-pinion focusing, covers. Lenses: 25mm Kellner, 12.5mm Orthoscopic, 6mm Orthoscopic, ¼" f.l. Ramsden, Barlow. $240. Contact Mike Knightstep, 608 Earle, Quanah, TX 79252. Phone (817) 663-6448.

FOR SALE — Celestron 8, special coatings, wedge, tripod, eyepieces (40mm, 25mm, 12mm, 6mm), diagonal, T-adapter and T-ring, piggyback camera mount. Mint condition, $800. Contact Bob Nelson, 8208 Big Bend Dr., El Paso, TX 79904. Phone (915) 755-2480.

FOR SALE — C-90, clock drive, 5mm, 18mm and 30mm oculars, star diagonal, T-adapter, 5x24 finderscope, carrying case, photo tripod adapter, wedge, and tripod. In excellent condition, $550. Contact Scott Nesvold, Route 4, Box 197, Northfield, MN 55057. Phone (507) 334-8693.

METEORITES

AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY.**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— *PLEASE SEND $1.00 FOR FULL COLOR CATALOG —*
Refundable on first order

FREE Complete Catalog Package. Just Write or Call.
Foreign $5.

We Sell And Ship To The World

Visit the largest and most complete telescope showroom in the United States

Scope City ® *Two Locations To Serve You*

"A division of Tomlin Industries, Inc."
679 Easy Street, Simi Valley, California 93065
(805) 522-6646 Mail Order & Showroom

3132 Pacific Coast Hwy
Torrance, Calif
(213) 326-3251

Open Mon - Fri 9-6 Sat 10-4

STS-41C Emblem Features Solar Max Repair

HART ✦ VAN HOFTEN ✦ NELSON
CRIPPEN ✦ SCOBEE

The Space Shuttle *Challenger* is depicted on this multi-colored embroidered emblem. NASA's official design shows the deployment of the Long Duration Exposure Facility (LDEF) and the repair of the Solar Maximum Mission Satellite, as reflected on an astronaut's helmet.

Wear some space history on your jacket or cap!

STS-41C 4" $4.95

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

---

vanishing point

going, going, gone

Act now! Beat the price increase!

TBR/OptiSystems has purchased a large quantity of "Criterion 4000" telescopes so that you may take advantage of our low price well beyond the July 1st Bausch & Lomb price increase. Save over fifty dollars by buying now!

Our supply of these telescopes won't last forever. Everyday that you wait, they are going, going......

BAUSCH & LOMB "CRITERION 4000" high-power Schmidt-Cassegrain, 4" mirror, 1200mm f/11 w/30mm (40x) & 18mm (67x) eyepcs., clock drive, 4x finderscope, tripod base, carrying case & more. Camera adaptable.

$479.00

TBR/OPTISYSTEMS

An Authorized Bausch & Lomb/Bushnell Mail Order House with a complete line of telescopes, binoculars, optical products & accessories.

P.O. Box 17129, Rochester, NY 14617, (716) 544-2264

GENTLEMEN: Please send your complete Astro Literature Pack for only $2.50 postage & handling (refundable w/1st order) to:

name ______
address ______
city ______ state ______ zip ______

When ordering any scope(s) just send check or M.O. (no CODs) for amount indicated, MC & VISA orders send card no. & exp. date. US shipping add $4.50/B&L 4000. NYS & Va. residents add State & Local sales tax. Send to:

TBR/OptiSystems
850 Hudson Ave., P.O. Box 17129, Dept. A084, Rochester, NY 14617
Offer expires 8/31/84. Allow 2-4 weeks for delivery.

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

COME IN AND COMPARE

Write for the world's finest telescope
Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

ASTROMART

FOR SALE — Meade Model 826 8" f/6 reflecting telescope with motor drive. Three eyepieces and 2x telenegative amplifier. Mint condition, best offer. Contact Greg Sippel, 1809 21st Ave., Sterling, IL 61081.

FOR SALE — 8" Meade reflecting telescope. Equatorial mount, clock drive, drive corrector, finderscope, 2" photo guide scope, Barlow lens, 4 filters, 25mm, 9mm, 6mm, and 4mm lenses. Good condition, $500. Contact Robert Gentz, RR #4, Mason City, IA 50401. Phone (515) 696-5658.

FOR SALE — 12.5" f/6.86 Optical Craftsman mirror, Novak mount, 2 diagonals, 2 spiders, Unitee mount system, 2 Meade research eyepieces, 6x30 finder, 2.7x Dakin Barlow, more. Contact Bob Swartzwelder, 914 Swatara Dr., Harrisburg, PA 17111. Phone (717) 939-0742.

FOR SALE — Observatory quality Celestron 11, special coating, wedge, custom portable pier, solar filter, 7 Tele Vue eyepieces, electric focus, setting circle lights, camera attachments and Miranda camera, LPR filter, many custom accessories. Better than new. Contact J. Packard, 5011 Fender, Lisle, IL 60532. Phone (312) 387-0600.

FOR SALE — ASTRONOMY back issues, first issue through present, excellent condition. Best offer, or will consider trade proposals involving baseball cards. Contact Bob Loper, 645 First St., Somers Point, NJ 08244.

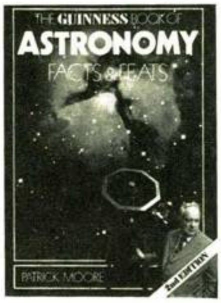
FOR SALE — All new 12½" reflector tube assembly. Parks 2.6" $^1/_{20}$-wave diagonal, f/6 Coulter thin mirror. Novak 9 point flotation cell, diagonal holder, spider, finder mount. North Star Telescope 14" x 75" cardboard tube (blackened inside, white enameled exterior) and 1¼" rack and pinion eyepiece holder. Home made 6x30 finder (achromatic). $450 plus transportation. Contact Ronald G. Samec, Clemson University, Kinard Physics Labs, Clemson, SC 29631.

FOR SALE — 17½" Odyssey 2 with finder bracket and 25mm eyepiece, no finder. Two years old, in excellent condition, $850 or best offer. Will deliver within 150 miles of New York metropolitan area but prefer pick-up. Contact Gerry Feulner at (201) 843-1543.

FOR SALE or TRADE — Meade Deep Space 10" reflecting telescope, motor drive, 25mm, 4mm eyepieces, 2x Barlow. Must sell, going back to school. $400 plus shipping, or best offer. Will trade for Schmidt-Cassegrain. Contact Mark Hasler, 3839 Buckley Rd., St. Louis, MO 63125. Phone (314) 544-3923.

FOR SALE — Byers 812 equatorial mount, brand new, every available accessory including Celestron 14 mounting brackets and tripod; Observadome 3-meter dome with motor and support ring; Pentex 4" equatorial refractor, brand new, with every accessory available. Contact Steve Spiegelman, 1309 S.E. Hawthorne Blvd., Portland, OR 97124. Phone (503) 663-7417.

FOR SALE — ASTRONOMY back issues, October 1973 through October 1982. In good to excellent condition, $220 or best offer. Send SASE to James R. Stimps, 3719 West 147th St., Hawthorne, CA 90250.



The Guinness Book of Astronomy Facts & Feats, 2nd ed.

by Patrick Moore

Enlarged and updated, this new edition of the classic book features new sections on Venus, Mars, Jupiter and Saturn, 8 pages of full-color photos, and a chapter on the new "Invisible Astronomy." The highlight of the book — the 92-page star catalogue — has been updated to the year 2000. Covers every branch of astronomy and is filled with illustrations.

289 pages, paperback $13.50

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

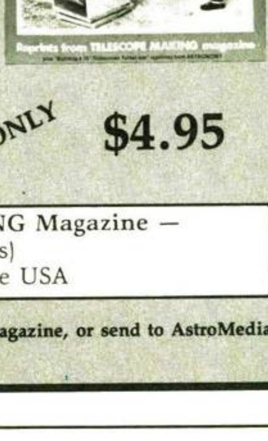
Creative Fashion Eyewear
111 Ocean Street, South Portland, ME 04106
(207) 799-6120

Complete Bushnell Line Featuring
B&L Criterion 4000   **$528.00 delivered.**
(ME residents add 5% sales tax)

Limited quantities at old price of $478.00 delivered.

Visa, Master Card or Money Order

WE WILL NOT BE UNDERSOLD



REVISED, EXPANDED SECOND EDITION

HOW TO BUILD A DOBSONIAN TELESCOPE

Reprints from TELESCOPE Making and **ASTRONOMY** Magazines

Would you like to build your own 10" telescope? Well, you can — and for a lot less time and money than you thought. Our 52-page booklet gives you complete instructions on how to build a 10" Dobsonian — plus helpful diagrams and plenty of informative articles and photographs on 12", 16" and 20" scopes. This new and expanded edition also tells you how to calculate bearing size, how to use a Poncet platform for deep-sky astrophotography, and how to use setting circles and your pocket computer to find your favorite celestial objects.

This is a complete Dobsonian manual — covering each step from choosing materials to aiming your new scope.

ONLY **$4.95**

Also available: TELESCOPE MAKING Magazine —
$12 per year (4 issues)
Add $2 per year outside the USA

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

CELESTRON TELEVUE MEADE

CELESTRON NIKON MEADE TELEVUE BAUSCH & LOMB SWAROVSKI

The Buyer's Guide To The Galaxy...

Meade
- 4" Spotter
- 2080/2120
- 826 Reflector

Celestron
- Super C-8
- C-80 Refractor
- Comet Catcher

Giant Binoculars
Tele-Vue Eyepieces
- Naglers
- Wide Fields
- Plossls

Precision Optics By
Berger Bros. Camera Exchange
Call or Write Joe or Tom:
209 Broadway (Rte 110)
Amityville, NY 11701
(516) 264-4160
We ship UPS in 48 hours.

CELESTRON NIKON MEADE TELEVUE BAUSCH & LOMB SWAROVSKI

CELESTRON TELEVUE MEADE

ASTROMART

FOR SALE — Quantum 4 with special coatings, 4" solar filter, and tripod adapter. Very good condition, must sell, asking $800. Contact Timothy Madonna, 625 Bridle Rd., Glenside, PA 19038. Phone (215) 884-5030 after 5 p.m.

FOR SALE — 25-year accumulation of mirrors, Pyrex blanks, lenses and related optical instruments. Send for list. Contact Edward Leibhardt, 9416 W. Bull Valley Rd., Woodstock, IL 60098.

FOR SALE — Coulter Odyssey 2, 17.5" aperture, 4 eyepieces, Barlow lens, 11x70 finder scope, *Sky Atlas 2000.0*. $1050 firm. Contact Hugh Hollon, 5537 N. Colony Blvd., The Colony, TX 75056. Phone (214) 370-4733.

FOR SALE — ASTRONOMY back issues, August 1973 to present, $200. Contact Tim Jennings, Rt. 2, Box 62-A, Woodlawn, VA 24381. Phone (703) 236-6526.

FOR SALE — Meade 10" f/6 mirror, one year old, mint condition, $150 (includes shipping and insurance). Contact Rick Clark, 117 Tanglewood Estates, Keene, NH 03431. Phone (603) 357-1652.

FOR SALE — 10" f/6 Meade research series Newtonian scope complete with massive equatorial mount, clock drive, guide scope, filters, eyepieces and many more accessories. Asking $1395. Contact J. Nastasi, 2649 Arthur La., Bellmore, NY 11710. Phone (516) 783-8611.

FOR SALE — Super Celestron-8, Byers drive, wedge, tripod, "Star-Brite" coatings, LPR filter, 26mm Plossl, star diagonal, high-tech black finish. In mint condition, $1200. Contact Preston Justis, 4096 Smokey Lake Dr., Virginia Beach, VA 23462. Phone (804) 467-7258.

FOR SALE — Tele Vue Plossls, brand new, unopened, 26mm and 10.4mm, $45 each. 6" f/4 Newtonian, Coulter optics, Novak diagonal assembly, low profile focuser, $100. Contact Salahuddin Shah, 145 West 79th St., New York, NY 10024.

FOR SALE — Celestron telescope, wedge, and adjustable Celestron tripod, $350 plus shipping. Celestron Comet-Catcher, $175 plus shipping. Both like new. Contact L.J. Emmerglick, 700 San Esteban, Coral Gables, FL 33146. Phone (305) 661-8981.

NEW ENGLAND ASTRO-OPTICS

• QUESTAR • MEADE • TELEVUE •
BUSHNELL/BAUSCH & LOMB • JSO
COULTER LUMICON

CATALOG PACKAGE $1.00
Box 834, Simsbury, CT 06070
203-658-0701
TCU 685 (7 Days) 70055,205

When writing to advertisers please mention you saw their advertisement in ASTRONOMY

STS 11 Emblem Features First MMU Flight

The Space Shuttle *Challenger* is shown on this multi-colored embroidered emblem. NASA's official design shows the first test of the Manned Maneuvering Unit (MMU) and one of the two satellites launched during this mission.

CHALLENGER
BRAND GIBSON McCANDLESS McNAIR STEWART

Great to wear on your jacket or cap!

STS 11 3¼" x 6" $4.95

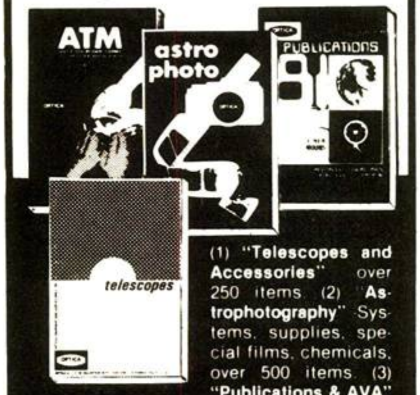
To order, use the AstroMedia order form bound into this magazine, or send to: AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

REMOTE CONTROL FOCUS

". . . FANTASTIC." K.R. *"I could not be more pleased."* B.F. *"It surpasses all your claims."* J.M.
For Celestron, Meade, Novak, Unitron & University. Send business-size S.A.S.E. for information.

**JIM'S MOBILE IND. • 1960 Co. Rd. 23
Evergreen, CO 80439 • (303) 277-0304**

4 OPTICA b/c CATALOGUES



(1) **"Telescopes and Accessories"** over 250 items. (2) **"Astrophotography"** Systems, supplies, special films, chemicals, over 500 items. (3) **"Publications & AVA"** over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) **"ATM"** - goods for the telescope maker, - over 400 items. Each catalog - $1.00; all four - $3.00. Also Receive: **FREE** Astronomical Events Calendar, a wealth of useful information, current discount price list and coupons. **FOREIGN** must add $3.50 for Airmail and send international postal money order or check drawn in U.S.$ on any U.S. bank. Astro equip. & supplies since 1939. Astro Aids, Celestron, Bushnell, Stellar Ventures, OPTICA b/c, Von Werner B&L, etc.

OPTICA

**OPTICA b/c Company
ASTRONOMY DIVISION
4100 MacArthur Blvd., Oakland, Calif. 94619**

LOS ANGELES OPTICAL CO.

Los Angeles' full-spectrum showroom telescope dealership, featuring:

MEADE INSTRUMENTS' full line of lenses, telescopes and accessories.

Stop by our large, well-stocked showroom for free demonstrations, assistance, information and literature regarding these and many other fine instruments, accessories, books, maps and charts.

Shown: Meade 4", 8", & 10" Schmidt-Cassegrain Telescopes

Authorized Meade Dealer

LOS ANGELES OPTICAL COMPANY
12129 Magnolia Blvd. (N.W. Corner, at Laurel Cyn. Blvd.)
Los Angeles (North Hollywood District), Calif. 91607
(818) 762-2206 master charge VISA AMERICAN EXPRESS Hrs: 10-6 Mon thru Sat

Equipment
Atlas

The Coming of Epoch 2000

by
Earle F. Dodds

Thuban was the Pole Star when the pyramids of Egypt were built. Polaris is now. Some 13,000 years from the present, the bright star Vega will lie near the northern celestial pole. And, as the pole moves among the stars, the right ascension and declination of all the stars and deep-sky objects also change.

You see, the right ascension and declination of every sky object is based on the Earth's rotation, not on anything fixed and unmoving in the heavens. Given enough time, the pole will swing through a complete circle and return, at least approximately, to its original position in 26,000 years. This precession, the gradual motion of Earth's axis of rotation, occurs because our planet's axis is tilted relative to its orbit. The never-ending gravitational pull of Sun and Moon on Earth's equatorial bulge makes the entire planet slowly precess like a child's toy top.

Most of the celestial handbooks in print today give coordinates as they were in the year 1950 — "Epoch 1950.0" in astronomical jargon. Until this year, 1950 was the standard epoch for all astronomers. But 1950 is now well behind us and coordinates for 1950 are no longer correct; in fact, the International Astronomical Union recently made the year 2000 the new standard epoch. Does this mean that we must throw out all our old observing books? Has 1950 gone totally sour?

The truth is that an amateur observer has no real need of coordinates — regardless of epoch — unless his telescope is equipped with fairly sophisticated setting circles. Even though the coordinates change, the stars themselves do not. Moreover, most positional data are given to a far higher degree of accuracy than amateur observers normally use, even those with setting-circle-equipped telescopes. And the truth, happily enough, is that changes due to precession, even over half a century, are generally less than the allowable error in setting or reading circles.

We might explore this idea a little. Let's assume that your telescope has setting circles six inches in diameter, with an r.a. circle graduated in 5 minute intervals and a declination circle in degrees. The spacings between graduations on the r.a. circle would be $\frac{1}{15}$ of an inch; those on the declination would be a bit over $\frac{1}{20}$ of an inch. How accurately can you actually point the telescope using these circles? It depends on the type of index provided, but I doubt the average observer can do much better than splitting the r.a. divisions into single minutes of time, and the declination spaces, with considerable certainty, into fifths of a degree.

How to Download
PRECESS.BAS

For the convenience of our readers, we regularly post programs appearing in the magazine in the Public Access area of CompuServe Information Services. If you are a subscriber to CompuServe, browse the posted files using ASTRONOMY as your keyword — you'll find William Bell's sunrise/sunset program SUNNY.ASC (published in the April issue) and PRECES.ASC there listed as ASCII files, plus programs and data of special interest to TELESCOPE MAKING and DEEP SKY magazine readers. You may also wish to send us *your* programs via CompuServe's EMAIL — our user identification number is 74206,110.

— *Richard Berry*

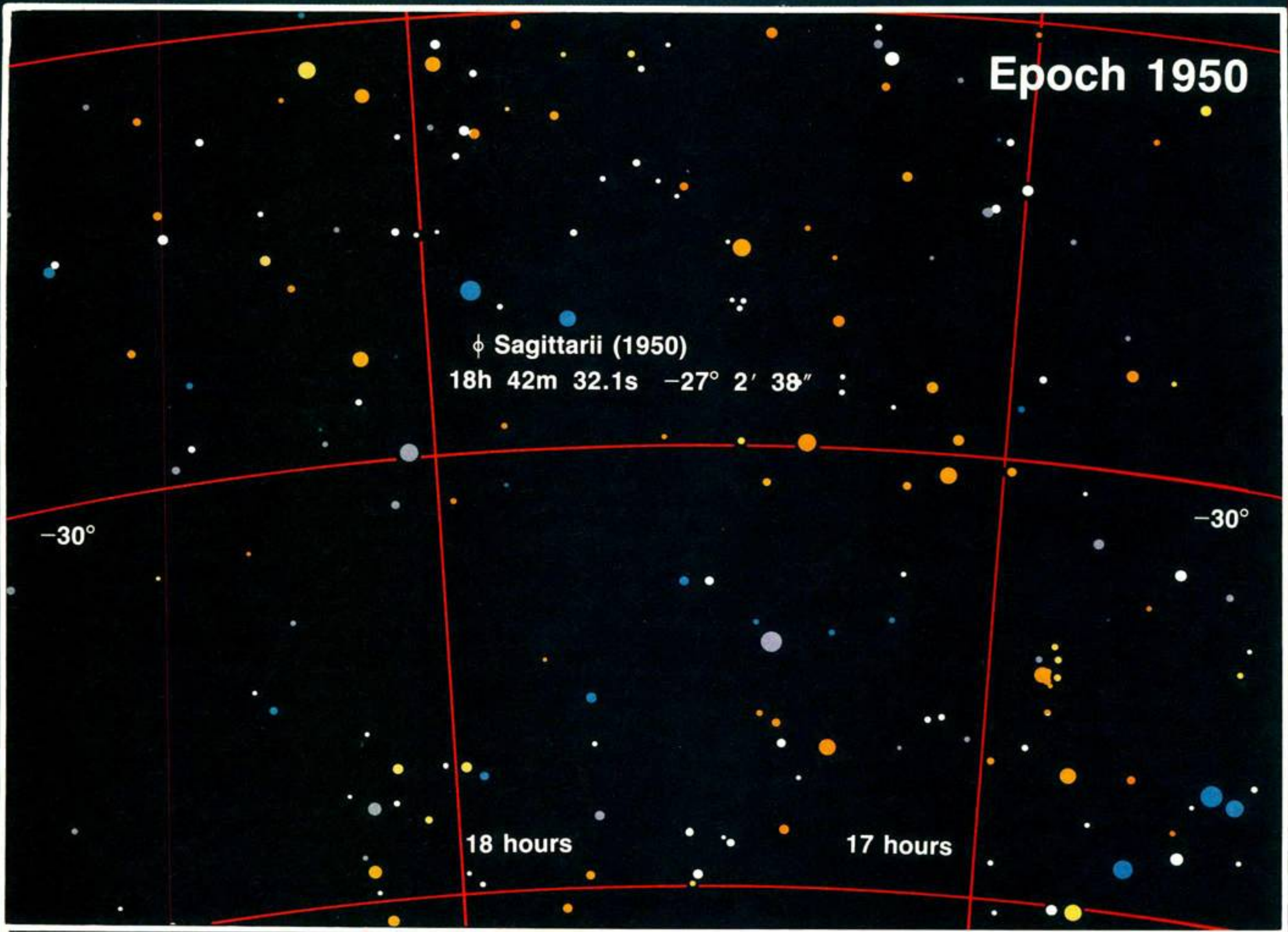
Better accuracy can be achieved by indexing the circles like those on an engineer's transit, by long verniers. These would allow reading to about 10 times the precision of a non-vernier circle. I have never seen a telescope indexed this way. Some commercial SCTs have short verniers on the r.a. circle, and these allow reading the r.a. circle to the nearest single minute of time. Big deal — I can do that well by eye.

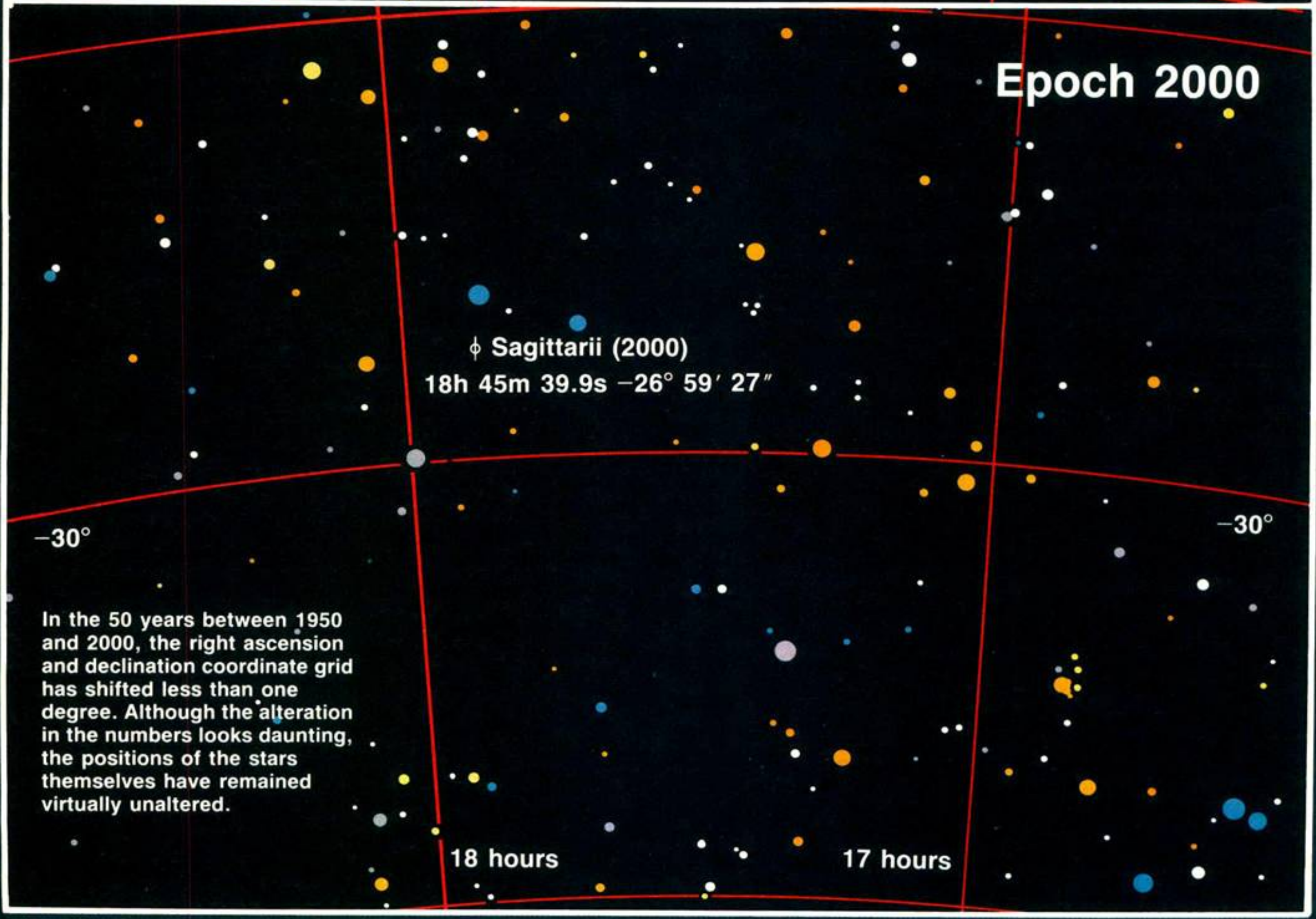
Now let's look at the magnitude of the changes that precession engenders during the half-century between 1950 and 2000. Each year, as the vernal equinox moves west, the r.a. of all stars on the celestial equator increases by 50 seconds of right ascension. North and south of the equator, the amounts of precession may be more or less; near 18 hours, far northerly stars decrease in r.a. as do far southern stars near 6 hours. Except near the poles, stars at 6 and 18 hours r.a. do not move north or south at all, while those at 12 hours move southward 19 arc-seconds and those at 0 hours move north by 19 arc-seconds per year.

That's all pretty complicated, but what it boils down to is that r.a. changes by roughly one degree in 72 years, while declination changes, on average, by about one degree in 300 years.

Of course you can't ignore precession. Suppose you want to plot some of the close doubles or faint galaxies listed in *Burnham's Celestial Handbook* in 1950 coordinates on a star atlas plotted in Epoch 2000 coordinates. Before you can locate them accurately, you must precess the 1950 coordinates given to 2000 — then you will plot them in the correct spot relative to the stars. (If you want to compute coordinates for one epoch given coordinates at another epoch, see the computer program in the box on pages 76 and 77.)

But for practical observing, because of the way most amateurs use their setting circles for finding things, precession doesn't matter much. Unless you have a permanently mounted "observatory" telescope, every time you set it up, you must align the polar axis with Earth's rotational axis. Let's assume that you make no errors in doing this. Now what? When you point the telescope at a bright "guidepost" star whose coordinates you know, if the scope is well made, the declination circle should read the declination of the star in 1984 coordinates — but remember that the declination coordinate changes slowly. For r.a., you turn the circle until it reads the star's r.a. Then, to find a deep-sky object, you move the telescope until the circles read its coordinates, and — *voila*! — the object is


Epoch 1950
ϕ Sagittarii (1950)
18h 42m 32.1s −27° 2′ 38″
−30°
−30°
18 hours
17 hours


Epoch 2000
ϕ Sagittarii (2000)
18h 45m 39.9s −26° 59′ 27″
−30°
−30°
18 hours
17 hours

In the 50 years between 1950 and 2000, the right ascension and declination coordinate grid has shifted less than one degree. Although the alteration in the numbers looks daunting, the positions of the stars themselves have remained virtually unaltered.

Precession in BASIC

The following program, written for Microsoft BASIC, transforms celestial coordinates for one epoch into those of another. The approach used for data entry is somewhat unusual; the program treats input and output as strings rather than numeric values. This is particularly handy for processing tabular data.

Lines 1140 through 1210 compute the constants of precession. Although the constants in this section assume a starting epoch of 2000, the program gives excellent accuracy for other initial epochs.

Lines 1250 through 1400 receive coordinate strings from the keyboard, separate them into numerical hours, minutes, and seconds, compute their decimal equivalents, and then convert the coordinates to radian measure. If you do not want to use the string method, rewrite the input lines for direct entry of hours and degrees as numeric variables. If you do not know the proper motion, enter 0,0 and the program will proceed.

Precession itself, the trigonometric core of the program, fills lines 1440 to 1520. Lines 1490 through 1510 resolve which quadrant the star lies in, and 1520 computes the new declination.

The routines from 1560 to 1690 convert decimal hour format into hours, minutes, seconds, and fraction of a second of right ascension, inserting zero into all empty places. These routines will vary depending on how your BASIC handles leading spaces, and may need revision for other BASICs.

Lines 1730 through 1850 convert the decimal degree declination into degrees, minutes, and seconds of arc. Like the r.a. routines, it may be necessary to modify them for other BASICs.

Finally, lines 1890 and 1900 print the original epoch and the coordinates input for it, then immediately below them the final epoch and its coordinates, thus allowing a

```
1000 ' ================= PRECESS.BAS =====================
1010 '   Written for Microsoft BASIC Version 5.211
1020 '      Published in ASTRONOMY, August 1984
1030 '         By J. P. POOL and R. L. Berry
1040 '
1050 PRINT "This program computes rigorous precession"
1060 PRINT "from a string representation of RA and DEC"
1070 PRINT "and returns a string representation of the"
1080 PRINT "precessed coordinates."
1090 '
1100 R=.01745329#
1110 '
1120 ' ====== compute the constants of precession ======
1130 '
1140 INPUT "INITIAL EPOCH";IN
1150 INPUT "  FINAL EPOCH";FI
1160 T1=FI-IN
1170 T=T1/100
1180 Z0=((2305.65*T)+(.302*T*T)+(.018*T*T*T))
1190 Z1=R*(Z0/3600)
1200 Z=(Z0+(.791*T*T))/3600
1210 TH=R*(((2003.829#*T)-(.426*T*T)-(.042*T*T*T))/3600)
1220 '
1230 ' ==== input coordinates and proper motion ====
1240 '
1250 PRINT "INITIAL RA: HH MM SS.F"
1260 INPUT"          ";RA$
1270 PRINT "INITIAL DC: +DD MM SS"
1280 INPUT"          ";DEC$
1290 INPUT "PROPER MOTION: <MUra,MUdec>";MURA,MUDC
1300 MURA=T1*15*MURA/3600:MUDC=T1*MUDC/3600
1310 IRA=VAL(MID$(RA$,1,2))
1320 IRA=IRA+VAL(MID$(RA$,4,2))/60
1330 IRA=IRA+VAL(MID$(RA$,7,4))/3600
1340 IRA=15*IRA
1350 IDC=VAL(MID$(DEC$,2,2))
1360 IDC=IDC+VAL(MID$(DEC$,5,2))/60
1370 IDC=IDC+VAL(MID$(DEC$,8,2))/3600
1380 IF MID$(DEC$,1,1)="-" THEN IDC=-IDC
1390 AL0=R*(IRA+MURA)
1400 DL0=R*(IDC+MUDC)
1410 '
1420 ' ======== precess the coordinates ===============
1430 '
1440 A=COS(DL0)*SIN(AL0+Z1)
1450 B=(COS(TH)*COS(DL0)*COS(AL0+Z1))-(SIN(TH)*SIN(DL0))
1460 C=(SIN(TH)*COS(DL0)*COS(AL0+Z1))+(COS(TH)*SIN(DL0))
1470 ALPMZ= ATN(A/B)/R
```

in the field.

The secret is this: unless the guidepost star and target are far apart, the precession for the two will be nearly identical, so the difference between their coordinates will have remained nearly constant. After much pondering and calculating, I have come to the conclusion that if you use a guidepost star which is relatively close to the target, it doesn't matter *what* epoch you use, providing you don't mix them.

Let's look at several real examples. Denebola, in Leo, is a good "worst case" subject because its declination coordinate changes faster than that of any other bright star — slightly over 20 seconds of arc a year. (Alpheratz in Andromeda moves almost as fast, but it moves northward, whereas Denebola's declination is decreasing.) In 1950 Denebola's declination, to the nearest second of arc, was +14° 51′ 06″. We'll round this off to 14.9°.

Precession causes Denebola's declination to decrease 0.1° every 18 years, so by 2005 it will have reached +14.5°. During the latter half of the 20th century Denebola's declination decreases about ¼°, which is just a little over the allowable error in *reading* the declination circle. It seems to me that this rather piddlin' change is insufficient to justify concern over Epoch 2000 coordinates.

What about the effect of precession on a star's r.a.? Let's look at Capella. Its precessional movement in r.a. is faster than that of any other bright star except Polaris. It is so far north — halfway to the pole — that the rule-of-thumb conversion (four minutes of r.a. is equal to 1° of angle) doesn't work. Capella's r.a. increases during the latter half of the century about 3.67 minutes of time, which would convert (at the equator) to almost a full degree of change in r.a. However, because of its high declination, the actual movement across the sky is less than half a degree. This is less than the field of a wide-angle eyepiece!

But are you likely to be using setting circles and coordinates to "find" Capella? Chances are that Capella would serve as a guidepost star to *set* your r.a. circle, so you'd probably do something like this: look up the declination of Capella, and you'd find that after rounding its position to the nearest 0.1° the declination coordinate would be: in 1950, +46.0°; today (1984), +46.0°; and in 2000, still +46.0°. In other words, the total change over half a century is not enough to affect the rounded-off value of the declination coordinate.

You'd then slew the tube in declination until the declination circle reads that value and set the declination clamp. Next, with the main polar axis clamp open, you'd point the tube in the general direction of Capella and sweep in r.a. until you picked up the star in the finder. After setting the r.a. clamp and throwing the clock drive into gear, you'd go to the main eyepiece,

```
1480 AL=(ALPMZ+Z)/15
1490 IF B<0 AND A>0 THEN AL=AL+12
1500 IF B<0 AND A<0 THEN AL=AL+12
1510 IF B>0 AND A<0 THEN AL=AL+24
1520 DL=ATN(C/SQR(1-C*C))/R
1530 '
1540 ' ==== convert decimal RA to HH MM SS.F string ====
1550 '
1560 RAH=FIX(AL)
1570 RAM=INT(60*(AL-RAH))
1580 RAS=INT(3600*(AL-RAH-(RAM/60)))
1590 RAF=INT(36000!*(AL-RAH-(RAM/60)-(RAS/3600)))
1600 RAH$=STR$(RAH):RAM$=STR$(RAM)
1610 RAS$=STR$(RAS):RAF$=STR$(RAF)
1620 IF RAH<10 THEN MID$(RAH$,1)="0"
1630 IF LEN(RAH$)=3 THEN RAH$=MID$(RAH$,2,2)
1640 IF RAM<10 THEN MID$(RAM$,1)="0"
1650 IF LEN(RAM$)=2 THEN RAM$=" "+RAM$
1660 IF RAS<10 THEN MID$(RAS$,1)="0"
1670 IF LEN(RAS$)=2 THEN RAS$=" "+RAS$
1680 PRA$=RAH$+RAM$+RAS$+RAF$
1690 MID$(PRA$,9)="."
1700 '
1710 ' ==== convert decimal DEC to DD MM SS string ====
1720 '
1730 IF DL<0 THEN SG$="-" ELSE SG$="+"
1740 DL=ABS(DL)
1750 DD=FIX(DL)
1760 DM=INT(60*(DL-DD))
1770 DS=INT(3600*(DL-DD-(DM/60)))
1780 DD$=STR$(DD):DM$=STR$(DM):DS$=STR$(DS)
1790 IF DD<10 THEN MID$(DD$,1)="0"
1800 IF LEN(DD$)=3 THEN DD$=MID$(DD$,2,2)
1810 IF DM<10 THEN MID$(DM$,1)="0"
1820 IF LEN(DM$)=2 THEN DM$=" "+DM$
1830 IF DS<10 THEN MID$(DS$,1)="0"
1840 IF LEN(DS$)=2 THEN DS$=" "+DS$
1850 PDC$=SG$+DD$+DM$+DS$
1860 '
1870 ' ==== print epochs and coordinate strings ====
1880 '
1890 PRINT "Epoch";IN;RA$+"   "+DEC$
1900 PRINT "Epoch";FI;PRA$+"   "PDC$
1910 PRINT
1920 INPUT "Another? <S>ame or <N>ew epoch";ANS$
1930 IF ANS$="S" OR ANS$="s" THEN GOTO 1230
1940 IF ANS$="N" OR ANS$="n" THEN GOTO 1140
```

check that the numbers were correctly keyed into the computer.

BASICs differ considerably. The limited accuracy of the trig functions in BASIC 5.211 introduces random errors in the fractional seconds figure in r.a. and the unit seconds digit in declination. BASICs with less precise trigonometric functions may err by ten seconds or more — it is a good idea to check that your BASIC handles trig functions to sufficient accuracy before trusting the output of this program.

Several examples, useful for checking your program, follow:

```
run
This program computes rigorous precession
from a string representation of RA and DEC
and returns a string representation of the
precessed coordinates.
INITIAL EPOCH? 2000
  FINAL EPOCH? 1755
INITIAL RA: HH MM SS.F
          ? 02 31 50.4
INITIAL DC: +DD MM SS
          ? +89 15 51
PROPER MOTION: <MUra,MUdec>? 0.232,-0.01
Epoch 2000 02 31 50.4  +89 15 51
Epoch 1755 00 43 42.2  +87 59 41
Another? <S>ame or <N>ew epoch? n


 INITIAL EPOCH? 2000
   FINAL EPOCH? 1984
 INITIAL RA: HH MM SS.F
           ? 11 49 03.5
 INITIAL DC: +DD MM SS
           ? +14 34 19
 PROPER MOTION: <MUra,MUdec>? -.034,-.12
 Epoch 2000 11 49 03.5  +14 34 19
 Epoch 1984 11 48 14.5  +14 39 41
 Another? <S>ame or <N>ew epoch? s


 INITIAL RA: HH MM SS.F
           ? 20 41 25.8
 INITIAL DC: +DD MM SS
           ? +45 16 49
 PROPER MOTION: <MUra,MUdec>? 0,0
 Epoch 2000 20 41 25.8  +45 16 49
 Epoch 1984 20 40 53.0  +45 13 21

Ok
```

center Capella in the wide angle ocular, then check the finder to be sure the star was centered there, too. You'd make whatever adjustments were necessary to center the star in each eyepiece. Then, and only then, would you loosen the clamp on the r.a. circle and turn it until the index read the exact r.a. of Capella.

What epoch would you use to set the r.a. circle? That depends entirely upon what kind of coordinates you have available for the objects you want to find, using the circles and Capella as the guidepost star. As for me, if I wanted to spend the evening studying Messier objects in and around Auriga, I'd use the 1984 epoch because I have a list of the 1984 coordinates of all the Messier objects, and as long as I use the same epoch for the guidepost star I plan to use for the targets, the current coordinates just may have some advantage. But, if I wanted to take Volume 1 of *Burnham's Celestial Handbook* and prowl around in Auriga trying to find all those objects listed on page 260, I'd use the 1950 coordinate of Capella in setting the r.a. circle because all that stuff on page 260 is listed by 1950 coordinates.

If you're not yet convinced, let's run some examples using Denebola as the guidepost star and M-66 as the target, and also using Capella as the guidepost star and M-38 as the target:

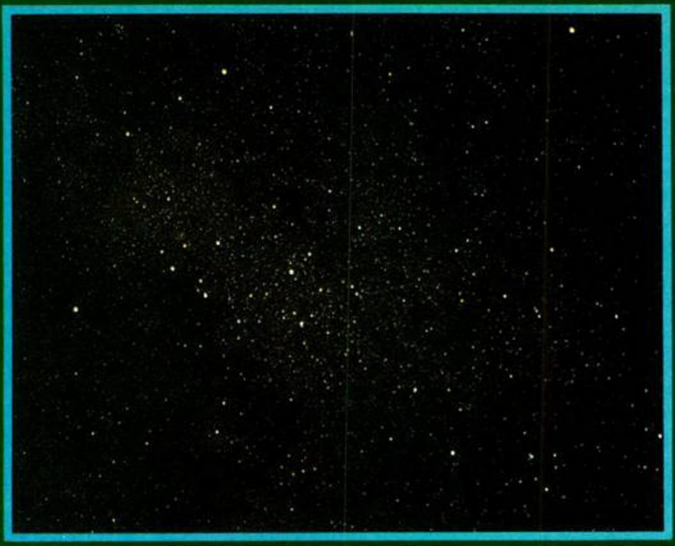
Epoch	1950		1983		2000	
	r.a.	dec.	r.a.	dec.	r.a.	dec.
Denebola	11:47	14.9°	11:48	14.7°	11:49	14.6°
M-66	11:18	13.3°	11:19	13.1°	11:20	13.0°
Difference	:29	1.6°	:29	1.6°	:29	1.6°
Capella	05:13	46.0°	05:15	46.0°	05:17	46.0°
M-38	05:25	35.8°	05:28	35.8°	05:29	35.8°
Difference	:12	10.2°	:13	10.2°	:12	10.2°

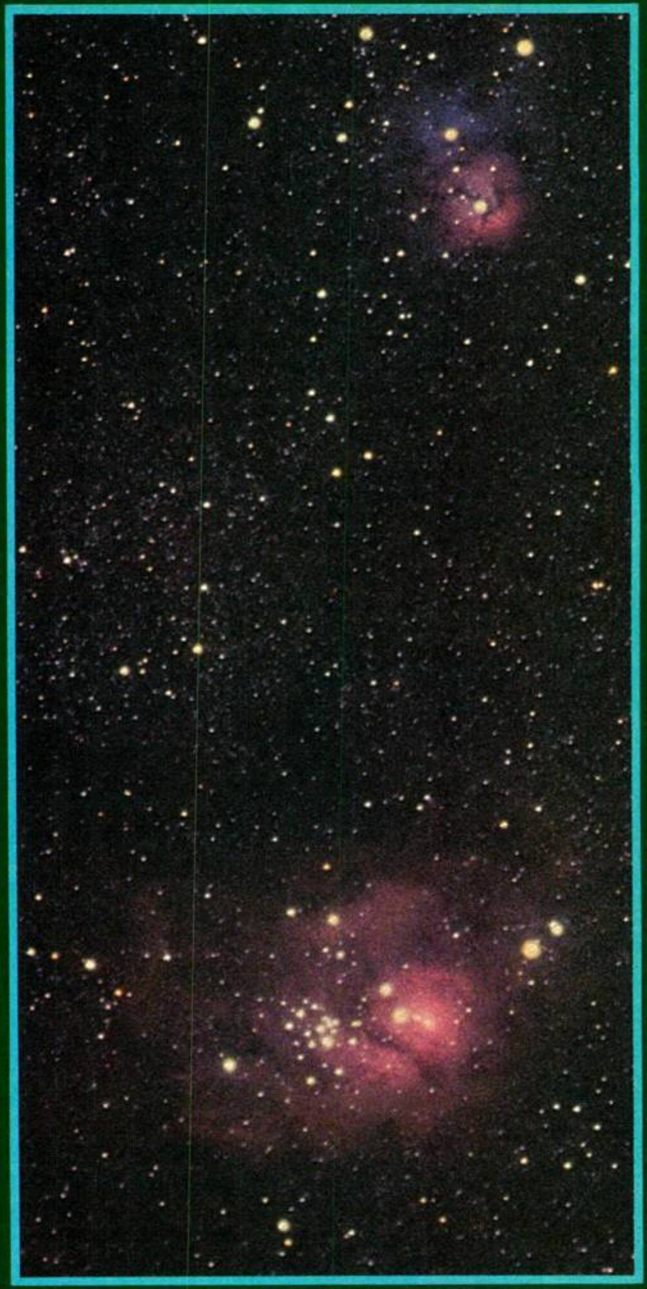
So, here's a rule of thumb to remember when you next find yourself thinking about this problem: If you use the same epoch for your guidepost star that you do for your target, it doesn't make a dime's worth of difference which epoch you use. *Just don't mix them up.*

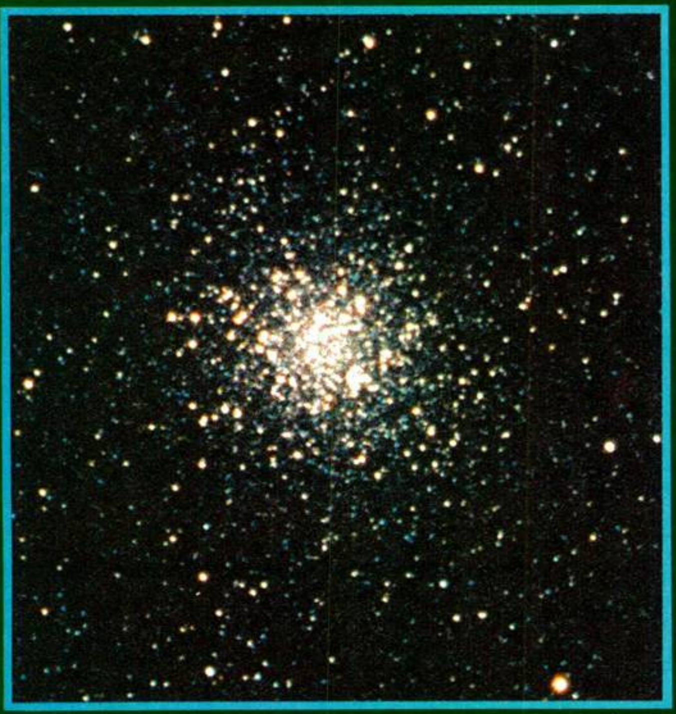
There is only one instance where you could get into any trouble at all, and that discrepancy is only a single minute of r.a., which, as previously pointed out, is about the same size as the error you'll probably make in reading the r.a. circle.

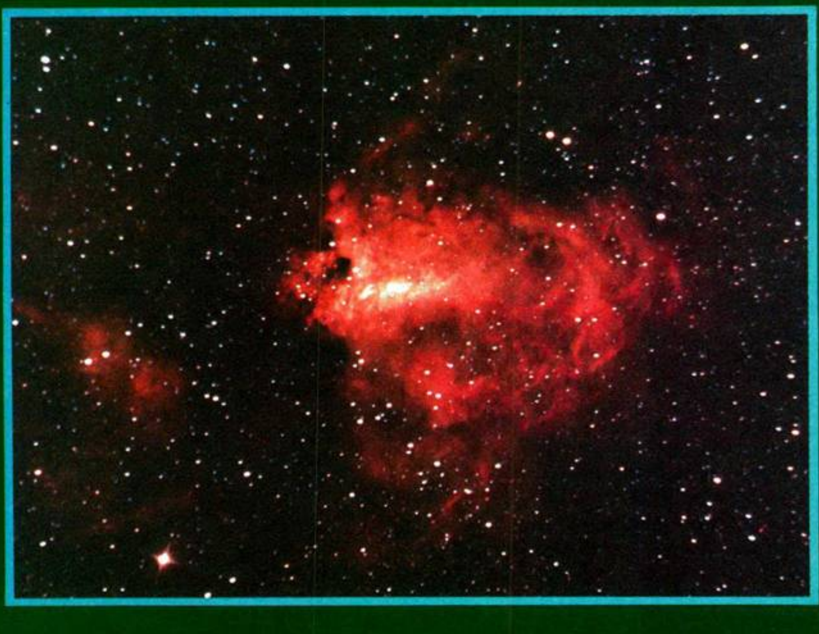
Maybe the obsession with coordinates comes about because the observing fraternity just isn't ready to accept ⅕° as the best that most telescopes can do. To me it makes very little difference — a ⅕° error gets the target "inside the ball park" almost every time.

Earle Dodds is an Alabama amateur whose no-nonsense attitude toward coordinates has kept him out under the sky and observing those target objects of his on a regular basis. He is the author of our current constellation series (the next will appear in the September issue), and he also writes a column for his local newspaper.







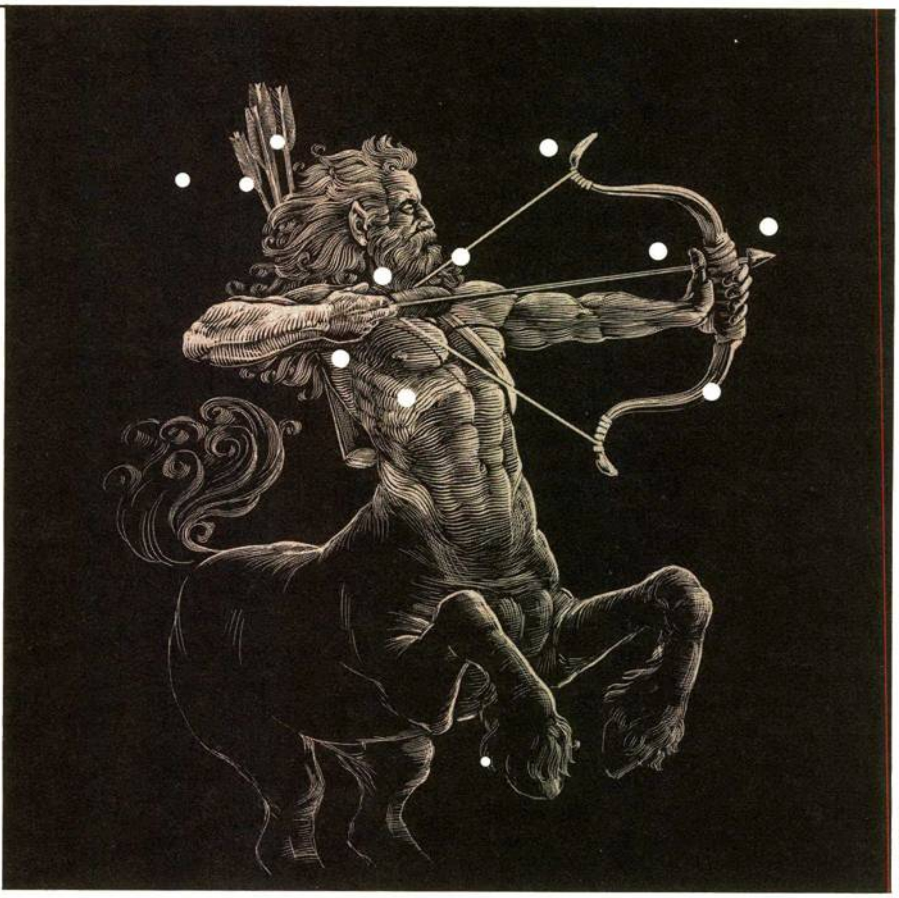


Above: The Lagoon Nebula, at bottom, is one of the sky's brightest and most distinctive emission nebulae; its bisecting dark lane and cluster of blue-white stars show in any small telescope. The Trifid Nebula, at top, shows a somewhat dimmer patch of emission nebulosity trisected by dust bands, and a bluish patch of reflection nebulosity. Photo by Bill Iburg. Top left: M-24, the Small Sagittarius Star Cloud, is a detached portion of Milky Way surrounded by regions of dark nebulosity. Photo by John Gleason. Middle left: The globular cluster M-22 is one of the finest in the sky, rivaling M-13 in Hercules. Photo by Roger Sliva. Bottom left: The Omega Nebula, M-17, has one of the highest surface brightnesses of all emission nebulae. Photo by Jack Marling.

Sagittarius

Sgr

Sagittarii



Keith Ward

The bright, southerly summer constellation **Sagittarius** marks the richest and most varied hunting ground for galactic deep-sky objects. This is because 0° galactic latitude and 0° galactic longitude — the direction of the center of our Galaxy — lies at a point roughly between the open cluster M-6 in Scorpius and the bright emission nebula M-8 in Sagittarius. Thus, when we look toward Sagittarius, we are looking toward the center of the Milky Way, the densest concentration of stars, gas, and dust in the sky.

M-8 (NGC-6523), the Lagoon Nebula, is one of the most spectacular of the emission nebulae; it glows at fifth magnitude and covers an area measuring 60′ x 35′. On a dark night the Lagoon Nebula is visible as a large, fuzzy naked-eye nebulosity, 4.7° west and slightly north of Lambda (λ) Sgr. Binoculars show **NGC-6530**, a bright open cluster inside M-8, and a large oval envelope of wispy greenish light. Small scopes show the nebulosity in two distinct sections, separated by the broad, dark, irregular dust band that gives the nebula its nickname.

Just a degree northwest of M-8 is **M-20** (NGC-6514), better known as the Trifid Nebula. M-20 is another emission nebula, but smaller and much dimmer than the sprawling Lagoon. The Trifid complex shines at eighth magnitude and measures 29′ x 27′ in extent; this excludes a faint patch of bluish reflection nebulosity on the northern tip of the emission nebulosity. Under dark skies the Trifid is a fine sight in binoculars, appearing as a round hazy spot slightly smaller than the Moon's diameter. With a 6-inch telescope, the Trifid becomes an exciting object: it shows a milky greenish irregular outline, trisecting dark lanes, and the just visible ghostly blue-green reflection gas.

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

Less than a degree northeast of the Trifid is the bright open cluster **M-21** (NGC-6531), a seventh-magnitude group of 50 stars compressed into an area spanning 12′. This group contains three dozen stars between magnitudes 8 and 12, making it a fine binocular sight. It is compact enough that large telescopes still show it well, providing you keep to your low-power eyepieces.

Moving back northward, past M-8 and M-20, we come to the brilliant open star cluster **M-23** (NGC-6494). This group holds 120 stars inside a Moon's diameter, and shines with a total magnitude of 7. Thus it is a fine binocular object — appearing as grainy, glistening sand on the black velvet of space — and a grand sight in any low-power telescopic field. The distance to M-23 is about 660 parsecs, its linear diameter some 5 parsecs.

Nearly due east of M-23 is one of the largest and brightest Messier objects — the starcloud **M-24**, also known as the Small Sagittarius Starcloud. It is a dense patch of Milky Way, detached from its surroundings by lanes of dark nebulae. The cloud shines at magnitude 4.5, and measures 120′ x 40′ across. Its entire area fits into a binocular field, making for a spectacular sight. Telescopes don't show the whole cloud, but several telescopic objects lie within and around the piece of Milky Way Galaxy.

The open cluster **NGC-6603**, which appears as a condensation in the rich background of starcloud M-24, measures 4′ across and contains 50 stars of 14th magnitude and fainter, giving it a total magnitude of 11.4. Telescopes operating at high power show this misty spot as being slightly nebulous, giving the impression of an unresolved globular. The object looks similar to NGC-2158 in Gemini, the little cluster sitting beside M-35. Also within the cloud is the bright, tiny planetary nebula **NGC-6567**, which glows at magnitude 11.5 and measures 11″ x 7″ in diameter. It is rather difficult to locate among the richness of the stellar background, but medium powers reveal the nebula's fuzziness. Seeing 6567's 15th magnitude central star is a difficult task even for large telescope owners: it is easily overpowered by the nebulosity. Another object immersed in M-24 is the dark nebula **Barnard 92**, which measures 15′ across and lies on the starcloud's northwest edge. On good dark nights it is visible as an obvious "hole" in the glittery backdrop of stars.

About 3.5° east of M-24 is the large and commanding open cluster **M-25** (IC 4725), a group which spans over a degree and contains 80 stars, including the bright Cepheid variable **U Sagittarii**. Binoculars or low-power telescopes must be used to view the entire group, whose combined magnitude is 6.2 (making it visible to the naked eye on dark nights). The Cepheid varies in brightness quite regularly from magnitude 6.3 to 7.1 over a period of 6.745 days. The cluster provides many bright comparison stars, so watching U Sgr and charting its fluctuations in brightness make for a good project.

Two bright Messier objects lie north of M-24. The first is the open cluster **M-18** (NGC-6613), a group of 18 stars loosely arranged in an area 7′ in diameter. The cluster's total magnitude is 8.0, making it bright in binoculars but not particularly impressive in larger telescopes because of its lack of concentration. The second is the high-surface-brightness nebula **M-17** (NGC-6618), most commonly known as the Omega Nebula. This is one of the sky's brightest and most easily observed emission nebulae; the familiar omega-shaped bar that gives M-17 its name is visible in binoculars, and wisps and streamers curving in all directions pop out in a large backyard telescope. M-17 is probably as distant as M-8 — about 1700 parsecs.

Sagittarius contains a large number of globular clusters, since it is in the direction of the galactic center, on which the halo of globulars is centered. The brightest and largest of these — one that rivals its big brother M-13 in Hercules — is **M-22** (NGC-6656), a magnitude 6.5 ball of stars measuring an enormous 17.0′ across and containing perhaps half a million stars. M-22 resolves fairly easily with high power, particularly with 6-inch or larger scopes. At 200x in an 8-inch scope, M-22 is a great big ball of sparkles, shimmering with feeble light from one edge of the field to the other. Located only a few degrees southwest, quite close to the star Lambda Sgr, is the smaller yet still impressive globular **M-28** (NGC-6626). Glowing at eighth magnitude, this cluster measures one-quarter degree in diameter. It is a fine sight in any telescope, and partially resolves at high power in a 5-inch telescope. Forming a triangle with globulars M-22 and M-28 is the 10th magnitude planetary NGC-6629, which measures 16″ x 14″ and lies in a rich center-of-the-Galaxy field, making it difficult to pick out of the background.

Four fine globulars lie inside the constellation's "Teapot": **M-54** (NGC-6715), **M-69** (NGC-6637), **M-70** (NGC-6681), and **NGC-6624**. All of these are roughly equivalent in size but differ somewhat in brightness. Because they are pretty small, they are difficult to resolve into stars. M-54 spans 6′ and shines at magnitude 9; M-69 is a 7.5 magnitude globular measuring 4′ across; M-70 is an 8th magnitude globular some 4′ across; and 6624 shines at magnitude 8.5 and measures 3′ from one end to the other.

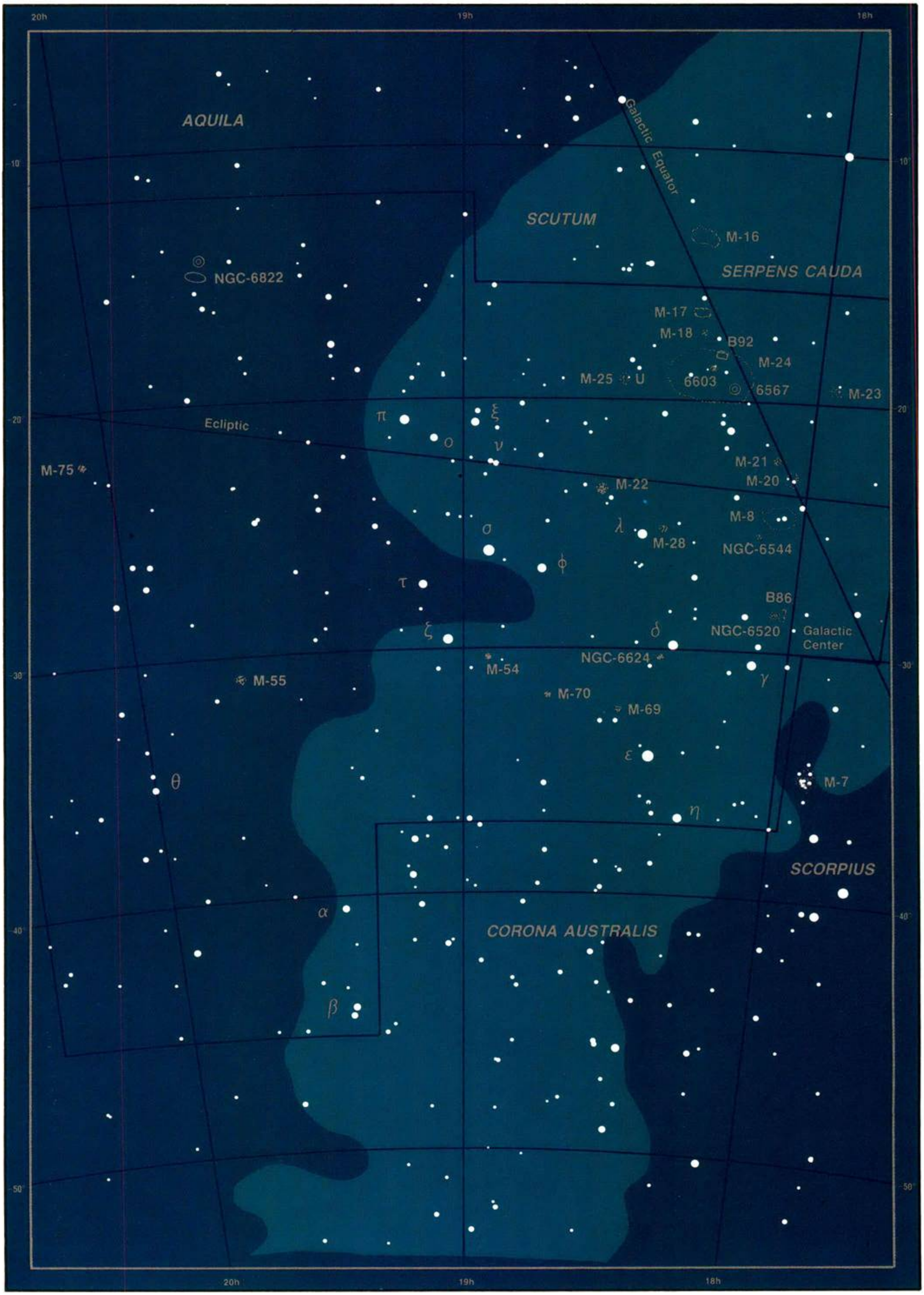
Farther east are two more globular clusters. **M-55** (NGC-6809) is a large, bright, and exceptionally loose globular whose southerly declination hurts its status with Northern Hemisphere observers. Were it placed high in the sky, this gem of a globular — seventh magnitude and 15′ in diameter — would rate among the finest. A low-power eyepiece shows a large, rather low-surface-brightness ball of stars that easily separates into distinct objects with additional magnification. **M-75** (NGC-6864), the last of the bright globulars in Sagittarius, shines at eighth magnitude and measures only 3′ across. It is roughly comparable in size and brightness to the four globulars that are located within the Teapot.

The elusive galaxy **NGC-6822**, also called Barnard's Galaxy (E.E. Barnard discovered it visually with a 5-inch refractor), and the tiny blue-green planetary nebula **NGC-6818** form an unusual pair of deep-sky objects up in the northeastern reaches of Sagittarius. The galaxy's total magnitude is 9, but that light is spread over an area measuring 20′ x 11′, making its surface brightness dismally low. Dark skies and wide fields of view are the answer to viewing this fellow Local Group member, which probably lies at a distance of about 500 kiloparsecs. The planetary measures only 22″ x 15″, shines at 10th magnitude, and generally looks stellar save for its greenish disk. At medium power, this object's slight fuzziness and telltale color should give it away.

Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.	N★	Mag.★
NGC-6494	M-23	⊙	17h 57.0m	−19°01′	7.0	25′	100	9....
NGC-6514	M-20	☐ER	18h 01.9m	−23°02′	9.0	29′ x 27′		
Barnard 86		☐D	18h 03.1m	−27°50′	—	4.5′ x 3′		
NGC-6520		⊙	18h 03.5m	−27°54′	9.0	5′	25	9...12
NGC-6523	M-8	☐E	18h 04.7m	−24°20′	5.0	80′ x 35′		
NGC-6530		⊙	18h 04.7m	−24°20′	7.5	10′	25	7....
NGC-6531	M-21	⊙	18h 04.8m	−22°30′	7.0	10′	50	9...12
NGC-6544		●	18h 07.2m	−25°01′	9.0	1′		
NGC-6567		☐	18h 13.7m	−19°04′	11.5	11″ x 7″		15.0
Barnard 92		☐D	18h 15.6m	−18°19′	—	15′		
NGC-6603		⊙	18h 18.4m	−18°26′	11.4	4.5′	50	14....
	M-24	SC	18h 18.4m	−18°26′	4.5	120′ x 40′		
NGC-⊙6613	M-18		18h 19.9m	−17°08′	8.0	7′	12	9...10
NGC-6618	M-17	☐E	18h 20.9m	−16°11′	6.9	46′ x 37′		
NGC-6624		●	18h 23.7m	−30°21′	8.5	3′		
NGC-6626	M-28	●	18h 24.6m	−24°52′	8.0	6′		
NGC-6637	M-69	●	18h 31.4m	−31°21′	7.5	4′		
IC 4725	M-25	⊙	18h 31.6m	−19°15′	6.0	35′	50	6...10
U		CV	18h 31.8m	−19°08′	6.3↔7.1	6.745d		
NGC-6656	M-22	●	18h 33.3m	−23°58′	6.0	18′		
NGC-6681	M-70	●	18h 43.3m	−32°18′	8.0	4′		
NGC-6715	M-54	●	18h 55.2m	−30°28′	9.0	6′		
NGC-6809	M-55	●	19h 40.1m	−30°56′	7.0	15′		
NGC-6818		■	19h 43.9m	−14°10′	10.0	22′ x 15″		15.0
NGC-6822		§Irr	19h 44.9m	−14°46′	9.0	20′ x 10′		
NGC-6864	M-75	●	20h 06.1m	−21°55′	8.0	3′		

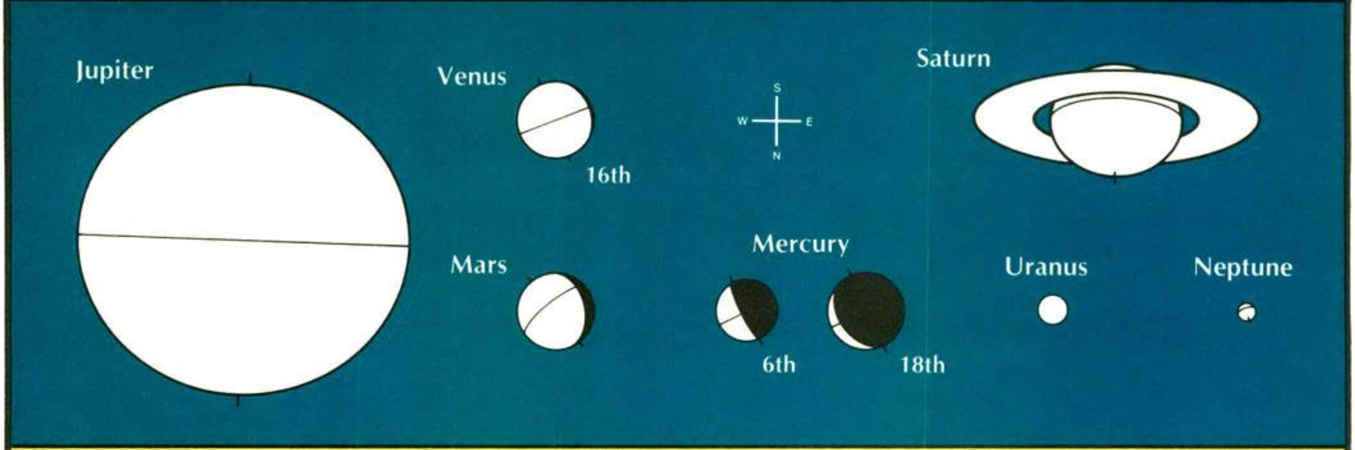
CV	*Cepheid Variable*
⊙	*Open Cluster*
●	*Globular Cluster*
SC	*Starcloud*
☐E	*Emission Nebula*
☐R	*Reflection Nebula*
☐D	*Dark Nebula*
■	*Planetary Nebula*
§Irr	*Irregular Galaxy*

N★ = number of stars, Mag.★ = magnitude range of cluster or magnitude of central star, (...) indicates many fainter.

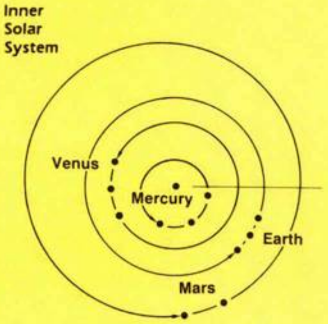

20h
19h
18h
AQUILA
Galactic Equator
-10°
10°
SCUTUM
M-16
NGC-6822
SERPENS CAUDA
M-17
M-18
B92
M-24
M-25
U
6603
6567
M-23
-20°
20°
Ecliptic
π
ξ
ο
ν
M-75
M-21
M-22
M-20
M-8
σ
λ
M-28
NGC-6544
φ
τ
B86
NGC-6520
Galactic Center
ζ
δ
NGC-6624
M-54
-30°
30°
M-55
γ
M-70
M-69
ε
θ
M-7
η
SCORPIUS
α
CORONA AUSTRALIS
-40°
40°
β
-50°
50°
20h
19h
18h

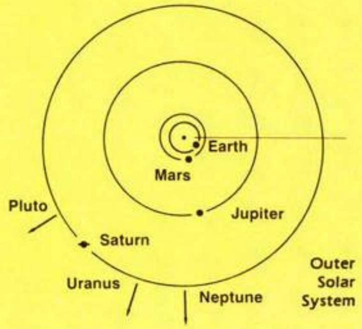
Planetary Data

August 1984


Jupiter
Venus
16th
S
W
E
N
Saturn
Mars
Mercury
6th
18th
Uranus
Neptune

		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.7	31.6′	—	1.01	—	—	128°56.0′	8h 46.3m	17°58.4′
		15	−26.7	31.6′	—	1.01	—	—	142°21.1′	9h 39.6m	13°59.8′
		31	−26.7	31.7′	—	1.01	—	—	157°46.5′	10h 38.6m	8°34.7′
Mercury	☿	1	0.4	7.7″	47%	0.88	0.47	249°31.6′	155°32.0′	10h 30.5m	7°54.6′
		15	1.4	9.8″	22%	0.69	0.45	288°53.0′	162°38.3′	10h 53.5m	2°45.6′
		31	4.2	10.4″	2%	0.64	0.37	345°28.1′	153°02.0′	10h 16.7m	6°50.5′
Venus	♀	1	−3.9	10.0″	98%	1.67	0.72	159°43.3′	141°08.4′	9h 38.7m	15°36.3′
		15	−3.9	10.2″	96%	1.63	0.72	182°25.4′	158°21.9′	10h 44.7m	9°30.9′
		31	−3.9	10.6″	94%	1.57	0.72	208°14.1′	178°02.3′	11h 57.2m	1°34.7′
Mars	♂	15	−0.2	10.3″	86%	0.91	1.43	283°21.1′	238°06.3′	15h 43.8m	−22°11.1′
Jupiter	♃	15	−2.5	43.9″	99%	4.48	5.21	281°54.4′	273°01.7′	18h 16.1m	−23°26.0′
Saturn	♄	15	0.6	16.5″	100%	10.04	9.88	226°19.8′	220°05.9′	14h 36.3m	−12°54.9′
Uranus	⛢	15	5.6	3.7″	100%	18.70	19.03	252°27.3′	249°09.3′	16h 32.4m	−21°53.7′
Neptune	♆	15	7.9	2.3″	100%	29.65	30.26	270°22.5′	268°24.5′	17h 55.9m	−22°14.8′
Pluto	♇	15	13.8	0.1″	100%	30.17	29.81	211°34.5′	209°16.3′	14h 14.3m	4°08.3′

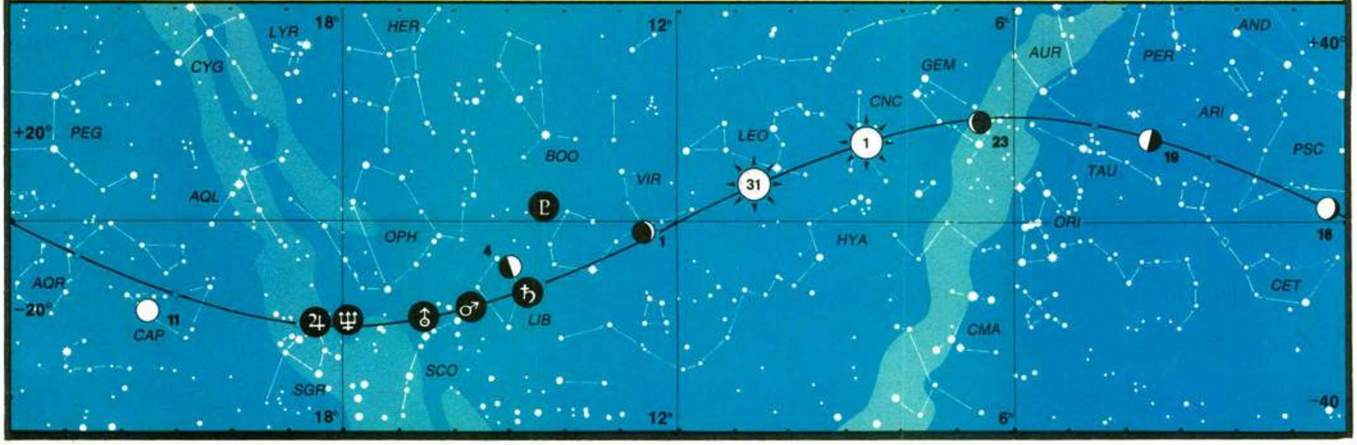

Inner Solar System
Venus
Mercury
Earth
Mars

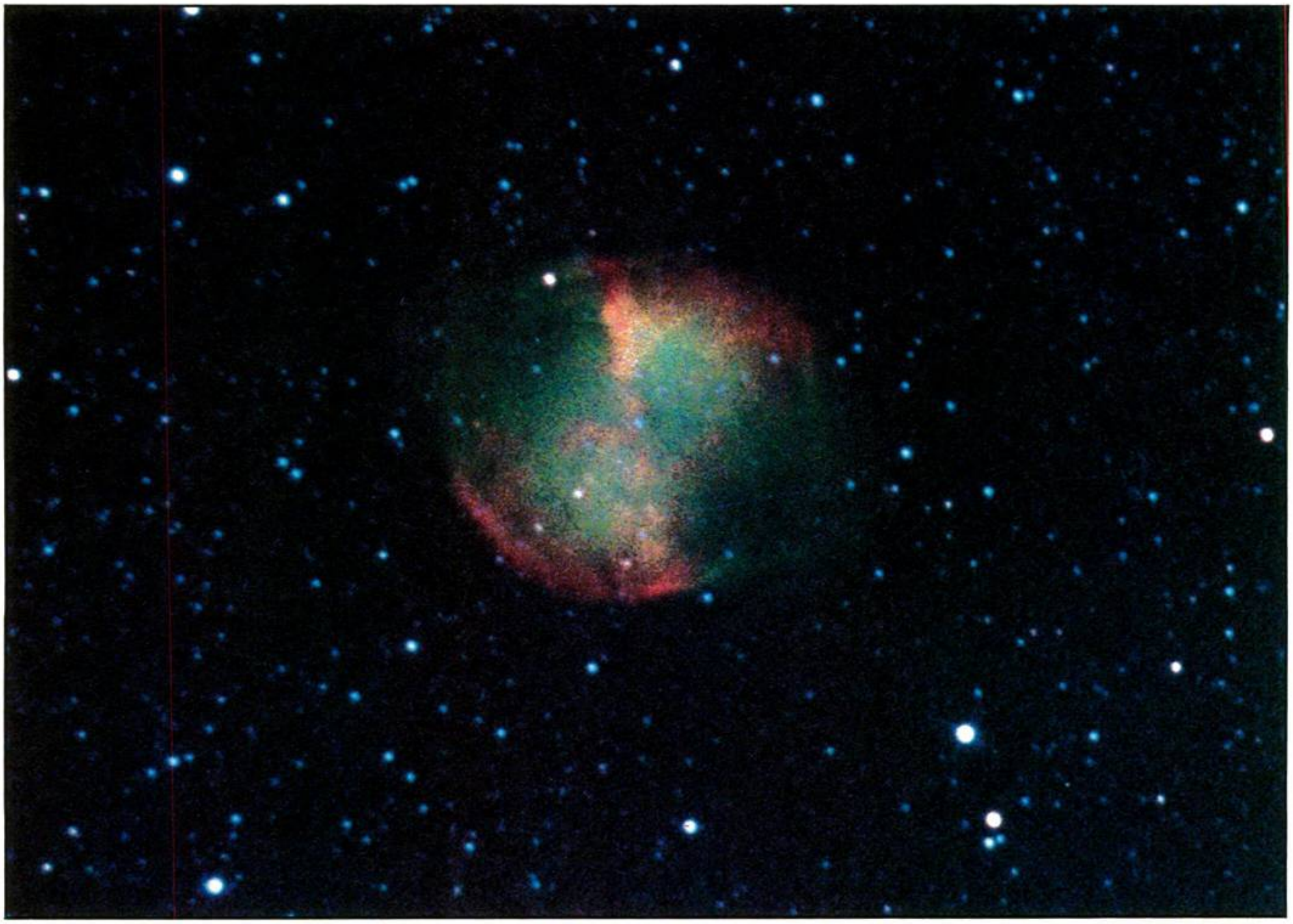

Earth
Mars
Jupiter
Pluto
Saturn
Uranus
Neptune
Outer Solar System

Moon Data

First Quarter............Aug. 4 at 2:33
Full Moon..............Aug. 11 at 15:43
Last Quarter............Aug. 19 at 19:41
New Moon.............Aug. 26 at 19:26
First Quarter............Sept. 2 at 10:30
Full Moon..............Sept. 10 at 7:01

Apogee: Aug. 15 at 4:51.....405,779 km.
Perigee: Aug. 27 at 16:54.....358,442 km.


LYR
18°
HER
12°
6°
AUR
AND
+40°
CYG
GEM
PER
CNC
+20°
PEG
LEO
1
23
ARI
19
BOO
PSC
VIR
TAU
31
AQL
ꝑ
ORI
16
OPH
HYA
4
AQR
CET
−20°
11
♃
♆
⛢
♂
♄
LIB
CAP
CMA
SCO
SGR
18°
12°
6°
−40



With the same equipment and methods detailed in last month's Photography in Astronomy column, Jack Newton took this portrait of M-27, the Dumbbell Nebula, in Vulpecula. He used VR-1000 film, a cold camera, Lumicon's Deep Sky filter, and a 20-inch f/5 telescope. The exposure ran 18 minutes.

Mercury

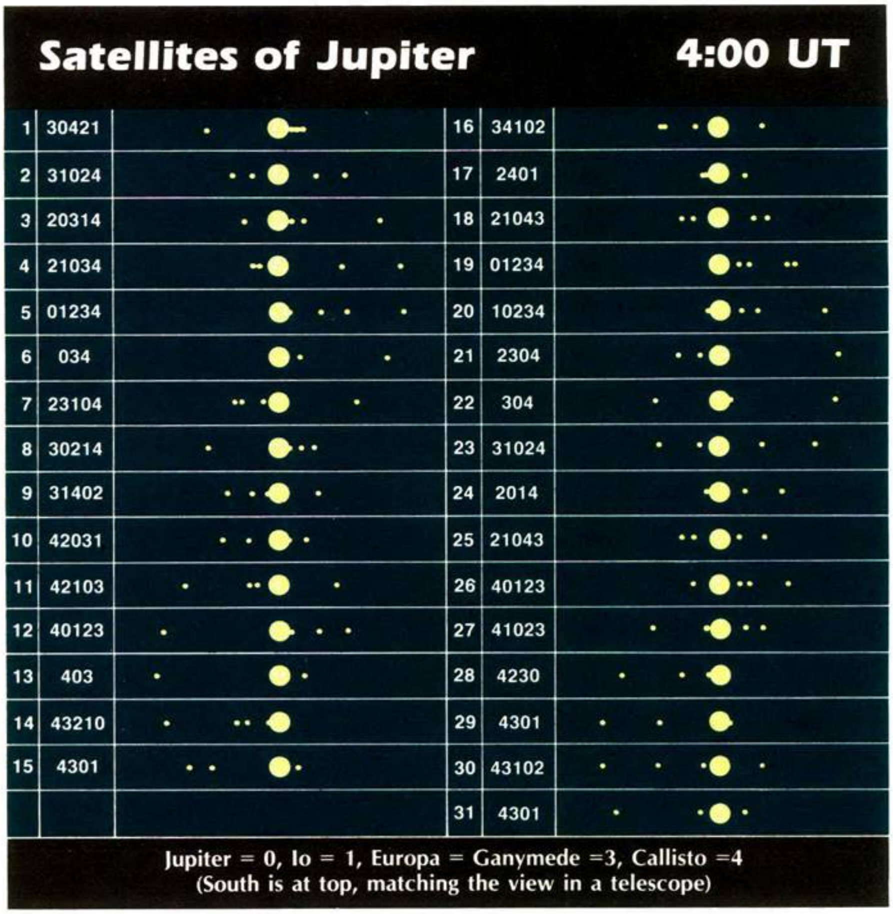
During the first week to ten days of August, Mercury concludes a poor apparition in the evening sky. It vanishes from view by about August 10th and passes through inferior conjunction into the morning sky on the 28th. Next month's morning elongation will be the second best of the year.

Venus

Venus' low elevation in the evening sky makes it more a participant in conjunctions than a telescopic target in its own right. As mentioned in Eye on the Sky, it will have pairings with Regulus (on the 7th), Mercury (on the 26th), and the Moon (on the 28th). These conjunctions are mostly wide — suitable for finder scopes or binoculars — but the meeting with Regulus would fit into a low-power eyepiece, since the two are only 67′ apart.

Mars

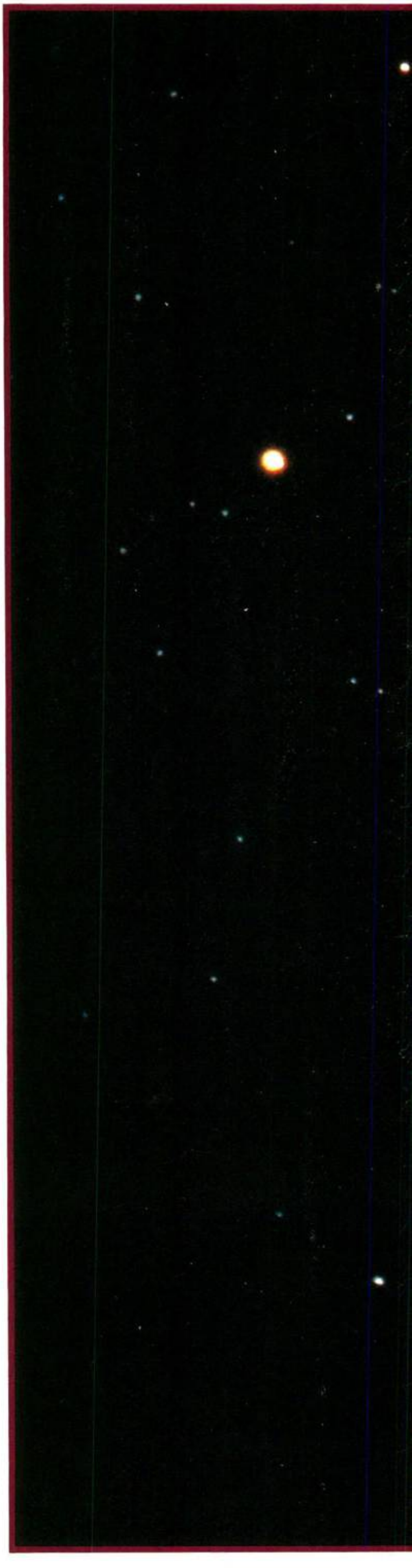
Moving steadily eastward as though trying to outrun the Sun, Mars will hold almost fixed in azimuth in the southwestern sky (if you observe it at the



Satellites of Jupiter **4:00 UT**

1	30421	16	34102
2	31024	17	2401
3	20314	18	21043
4	21034	19	01234
5	01234	20	10234
6	034	21	2304
7	23104	22	304
8	30214	23	31024
9	31402	24	2014
10	42031	25	21043
11	42103	26	40123
12	40123	27	41023
13	403	28	4230
14	43210	29	4301
15	4301	30	43102
		31	4301

Jupiter = 0, Io = 1, Europa = Ganymede =3, Callisto =4
(South is at top, matching the view in a telescope)



same time relative to sunset), but will drop 4° in elevation during August. Mars' size is steadily shrinking, but observers whose telescopes have long focal lengths and who are blessed with steady seeing conditions will still be able to make out many of its albedo markings.

Asteroids

1 Ceres (magnitude 8.1) is moving northeastward across the Taurus-Cetus border. On the night of August 15-16, it will pass about 31 seconds of arc south of the 3.7 magnitude star Xi (ξ) Tauri (α = 3h 27m 10.1s, δ = 9° 43′ 58″, epoch 2000.0). Ceres' positions:

10th: 3h 22m 10.1s, 9° 32.5′
20th: 3h 29m 52.9s, 9° 50.3′

Ceres rises about 12:30 a.m. local daylight time on the 15th.

2 Pallas (8.8) moves southwestward in western Pisces; it comes to opposition September 6th. Its positions:

10th: 23h 6m 11.4s, 7° 15.4′
20th: 23h 0m 10.7s, 5° 41.9′

Pallas rises around 8:30 p.m. local daylight time in mid-August.

3 Juno is in conjunction on August 7th; 4 Vesta is in conjunction on August 10th.

For convenience in plotting their positions in a star atlas, all asteroid coordinates are given for the epoch 2000.0.

Jupiter

Jupiter halts its retrograde motion on August 29th; it is then about 2° northwest of Lambda (λ) Sagittarii, the star at the top of the Teapot's lid. Though you can enjoy viewing the details of Jupiter's atmosphere when you observe from your backyard (or almost anywhere with a unclouded sky), take the trouble sometime in early or late August — when the Moon is out of the way — to head out into the country. There, you'll be able to observe Jupiter and its moons with low magnification and see it amidst the rich splendors of the southern Milky Way.

Right: Diego Meozzi wins the "Best Astro-Photo" award with his shot of M-13 in Hercules. He used an 8-inch SCT, a 2x telecompressor, 3M 1000 film, and a 30-minute exposure. Above: Jim Baumgardt caught the May 15 penumbral lunar eclipse with a 10-inch f/5 scope, K-64, and 1/60-second exposure.

Saturn

Saturn has about the same elevation in the evening sky as Mars, but it lies farther to the west and sets about half an hour earlier. You'll be able to keep Saturn in view for several weeks more, but at the price of seeing conditions that will grow increasingly worse as its elevation drops. During August and early September, look just to the west of the planet's disk — can you make out the shadow that the planet casts on the rings? Use medium to high magnification and wait for moments of steady seeing.

Uranus

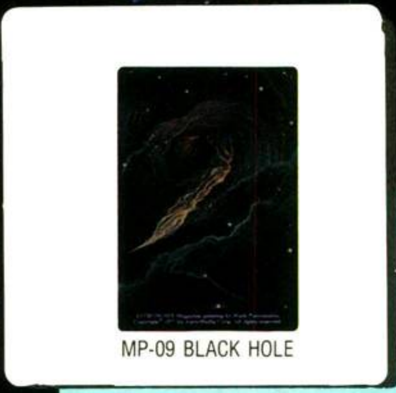
Uranus spends all of August nearly motionless about 30 arc-seconds south-southeast of the 4.5 magnitude star Omega (ω) Ophiuchi. Uranus has a magnitude of 5.6; its greenish disk (3.7″ across) can be readily spotted at medium or high power.

Neptune

Neptune is near the western end of its retrograde loop; it is stationary September 9th. Located about 2° northwest of the Trifid Nebula (M-20) in Sagittarius, the planet lies in a rich Milky Way field, but is easy to find. Look for a greyish-green disk 2.3″ across, and shining at 7.9 magnitude.

Explore the Universe from Your Living Room

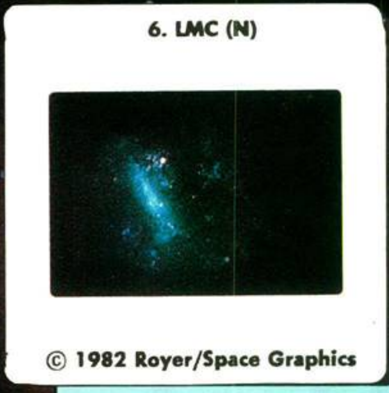
These 4 sets of 35mm slides take you on a voyage of discovery into the universe. From the comfort of your home, you can explore our Solar System, thrill to the wonders of the Milky Way, and tease your imagination with glorious deep-space vistas by renowned space artists.



Imagination Turned Loose!

From its fantastic collection of dramatic, scientifically-accurate astronomical art, ASTRONOMY magazine proudly presents an artists' selection of unique images in color slide format. Perfect for illustrating lectures and talks, these four dozen slides can add that exciting "you are there" touch to any presentation. From the brown dwarf stars that may lurk in the vast distances between the stars, to a billion-years-ago eruption of the mighty Olympus Mons volcano on Mars, these slides are tops! Set includes works by artists Adolph Schaller, Mark Paternostro, Rick Sternbach, and John Clark. Descriptive brochure included. 48 slides (all color).

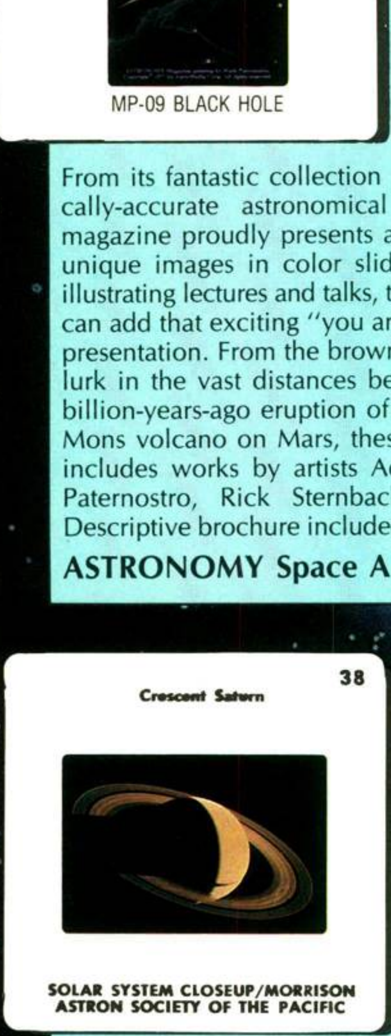
ASTRONOMY Space Art **$36.95**



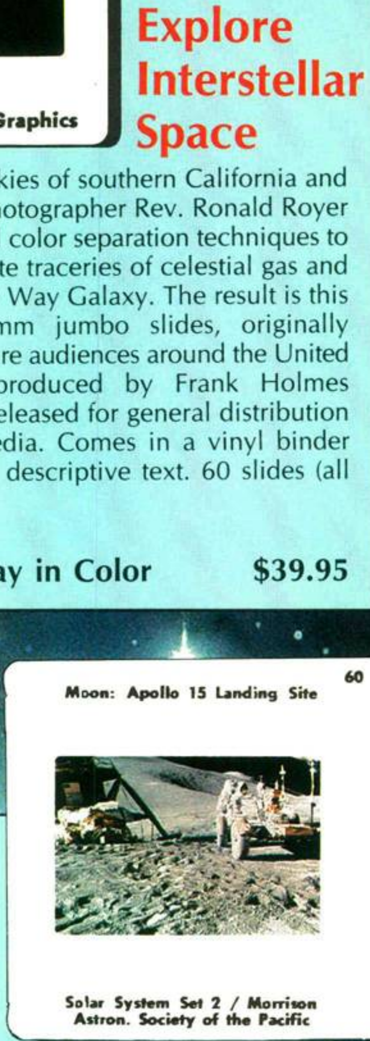
Explore Interstellar Space

Under the dark skies of southern California and Australia, astrophotographer Rev. Ronald Royer employed special color separation techniques to record the delicate traceries of celestial gas and dust in our Milky Way Galaxy. The result is this fine set of 35mm jumbo slides, originally presented to lecture audiences around the United States, now reproduced by Frank Holmes Laboratory and released for general distribution through AstroMedia. Comes in a vinyl binder complete with a descriptive text. 60 slides (all color).

The Milky Way in Color **$39.95**



Astronomical Society of the Pacific


Moon: Apollo 15 Landing Site
60
Solar System Set 2 / Morrison
Astron. Society of the Pacific

Voyages of Exploration
Solar System Close-Up

Part 1

Voyager, Viking, Mariner, Pioneer, Venera — you too can own fabulous images from humankind's exploration of the Solar System. Selected from NASA's image archives by Dr. David Morrison, noted planetary scientist and president of the Astronomical Society of the Pacific, these fifty slides bring the new era in Solar System exploration right into your living room! Perfect for the inquisitive layman — or put on your own astronomical slide show! 50 slides (24 in color).

Solar System — 1 **$34.95**

Part 2

"When Dr. Morrison selected his first set of fifty slides, he and the A.S.P. staff agonized over all the magnificent views we had to leave out." That's how the Astronomical Society of the Pacific came to release Part 2 of their fabulous Solar System Close-Up slides. Fifty new images; no duplicates with Part 1. Includes the Soviet color images of the surface of Venus, spectacular vistas of planet Earth, and the satellites of Saturn. 50 slides (25 in color).

Solar System — 2 **$34.95**

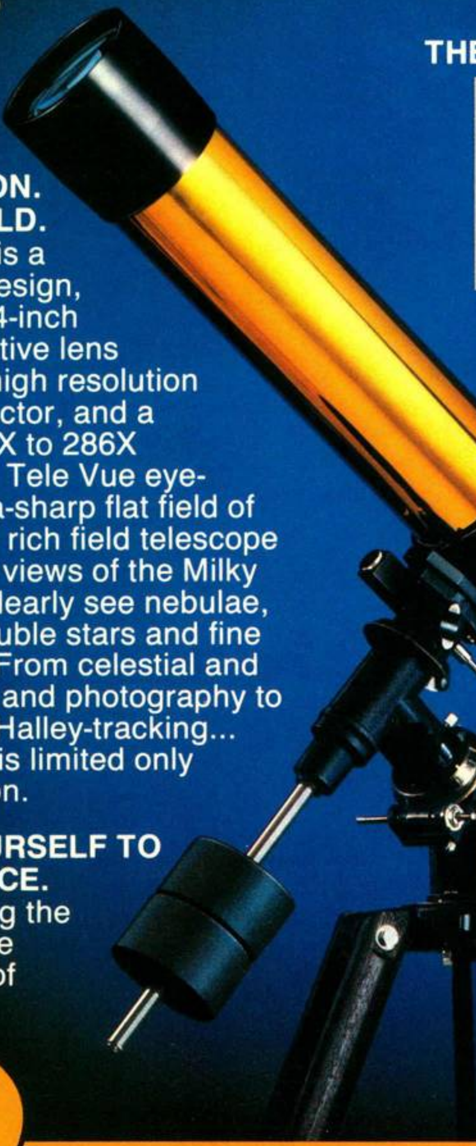
Each A.S.P. slide set includes a descriptive booklet.

SAVE! Order both Solar System sets for only $62.50!

To order, use the AstroMedia order form bound into this magazine, or send to AstroMedia Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

THE DIFFERENCES ARE CLEAR

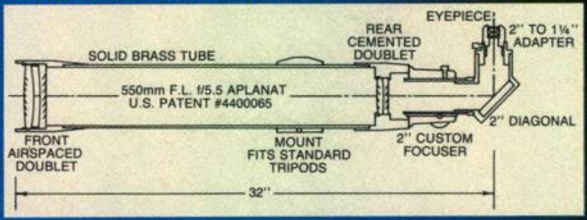
There was a time when beauty and function were inseparable. Telescopes were created with both technical excellence and aesthetic appeal. Today, these qualities rarely coexist in *any* instrument. The Renaissance, made in the U.S., is a notable exception, combining 19th century craftsmanship with 20th century optics in a compact, solid brass format.



HIGH RESOLUTION. ULTRA-WIDE FIELD.
The Renaissance is a patented Nagler design, with a 4-element, 4-inch multi-coated objective lens that provides the high resolution of the classic refractor, and a power range of 10X to 286X (using appropriate Tele Vue eyepieces) for an ultra-sharp flat field of up to 5°. This true rich field telescope offers spectacular views of the Milky Way. And, you'll clearly see nebulae, galaxies, close double stars and fine planetary details. From celestial and terrestrial viewing and photography to once-in-a-lifetime Halley-tracking... The Renaissance is limited only by your imagination.

INTRODUCE YOURSELF TO THE RENAISSANCE.
Tele Vue is offering the Renaissance at the remarkable price of $895.00, with your choice of a 7.4 to 26mm Plössl eyepiece. A matching equatorial mount, with slow-motion control, is $375.00. Send check or postal money order for $895.00 ($1,270.00 with mount). Shipping charges C.O.D.
NY residents please add sales tax.

THE CLASSIC REFRACTOR...REDESIGNED.


EYEPIECE
REAR CEMENTED DOUBLET
2" TO 1¼" ADAPTER
SOLID BRASS TUBE
550mm F.L. f/5.5 APLANAT
U.S. PATENT #4400065
2" DIAGONAL
FRONT AIRSPACED DOUBLET
MOUNT FITS STANDARD TRIPODS
2" CUSTOM FOCUSER
32"

TeleVue
15 Green Hill Lane
Spring Valley, NY 10977
(914) 354-4262

the RENAISSANCE™

SUPER C8 PLUS!

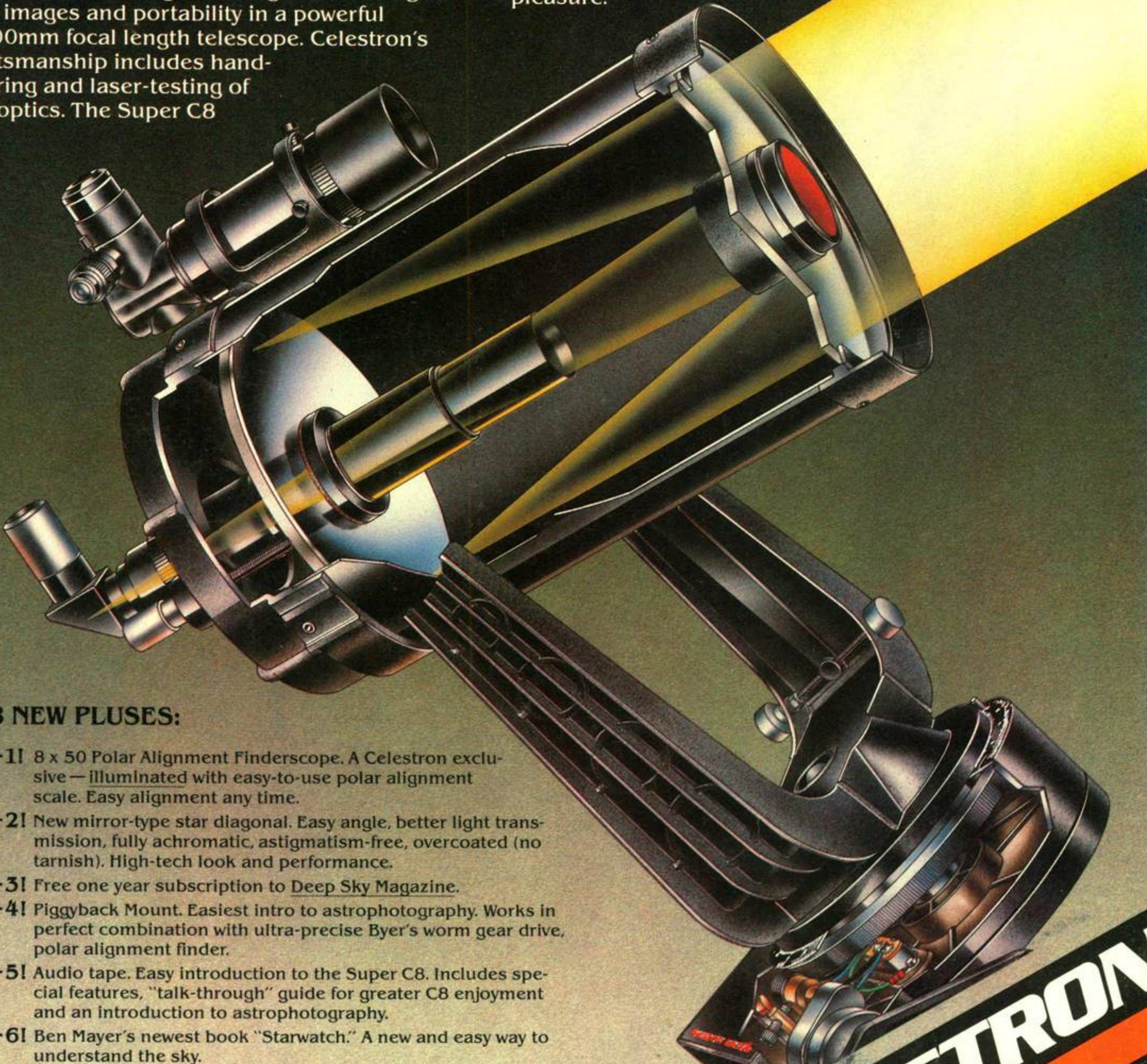
Look into our Super C8 Plus:
The Secrets That Make Celestron Stand Alone.

Only Celestron combines state-of- the-art technical advances with a vast array of practical advantages.

Celestron's world-renowned optical design and Celestron Certified Diffraction-Limited Optics assure you of the best optical value available today. The Schmidt-Cassegrain design means bright, f/10 images and portability in a powerful 2,000mm focal length telescope. Celestron's craftsmanship includes hand-figuring and laser-testing of the optics. The Super C8 features a superb Byer's worm gear drive, the most accurate clock drive available today, a patented (pending) design built with special Swiss machine tools.

But even the finest instrument must be used and enjoyed. So we've taken the mystique out of astronomy.

Owning a Celestron Super C8 Plus is exciting. Now we've added 8 new pluses for even greater pleasure.



8 NEW PLUSES:

- **+1!** 8 x 50 Polar Alignment Finderscope. A Celestron exclusive — illuminated with easy-to-use polar alignment scale. Easy alignment any time.
- **+2!** New mirror-type star diagonal. Easy angle, better light transmission, fully achromatic, astigmatism-free, overcoated (no tarnish). High-tech look and performance.
- **+3!** Free one year subscription to Deep Sky Magazine.
- **+4!** Piggyback Mount. Easiest intro to astrophotography. Works in perfect combination with ultra-precise Byer's worm gear drive, polar alignment finder.
- **+5!** Audio tape. Easy introduction to the Super C8. Includes special features, "talk-through" guide for greater C8 enjoyment and an introduction to astrophotography.
- **+6!** Ben Mayer's newest book "Starwatch." A new and easy way to understand the sky.
- **+7!** Fingertip azimuth adjustment.
- **+8!** A Latitude scale and bubble level for more ease in polar alignment.

For Dealer Locations, Catalogs, Information, Technical Data Sheets

CALL FREE 1-800-421-1526

(Mon-Fri; 8 - 4:00 Pacific Time; Continental USA only)

CELESTRON INTERNATIONAL, P.O. Box 3578B8,
2835 Columbia St., Torrance, CA 90503 (213) 328-9560

CELESTRON®
PRECISION OPTICS